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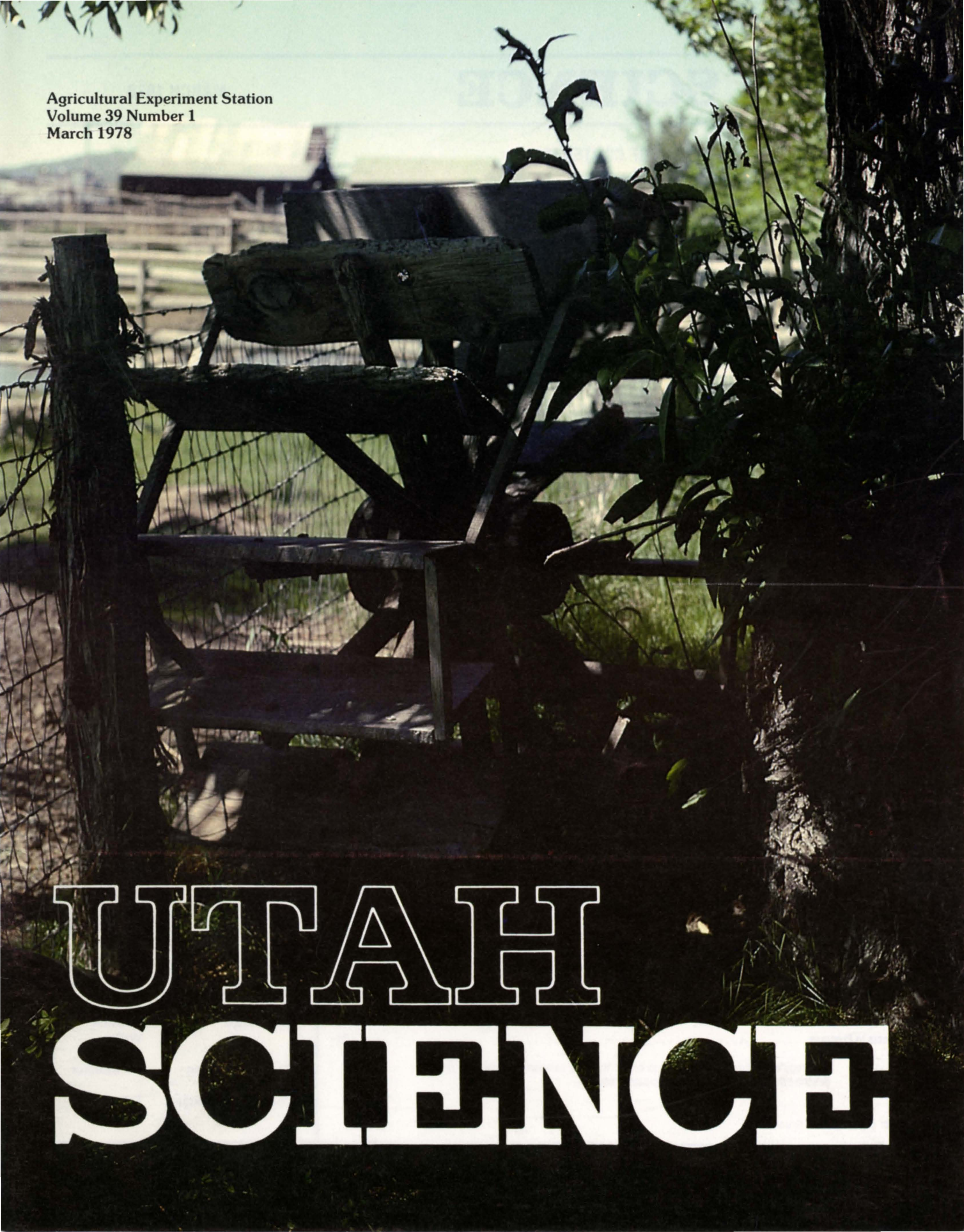

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Cover photo by Carol Grundmann

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Breeding Grasses for Western Range

Kay H. Asay, Douglas A. Johnson, and Douglas R. Dewey

Although western rangeland will continue to be valued for recreational and aesthetic qualities, these vast areas must play an expanded role in supplying America's red meat supply in the future.[1] Admittedly, attaining a high level of productivity without upsetting the delicate environmental balance is difficult. Utilizable productivity on western rangelands has been improved markedly in recent years, however, through control of undesirable vegetation and reseeding with forage grasses, primarily crested wheatgrass. Although these seedings have been valuable, their contribution might have been enhanced by the use of improved strains of crested wheatgrass.

The USDA's Agricultural Research Service (in cooperation with Utah State University) has recently initiated a range grass breeding program. Our goals in this program are: 1) to improve seedling establishment and persistence under drought, 2) to increase forage and seed yield, 3) to improve forage quality, and 4) to develop resistance to plant pests. Each objective presents a complex series of problems whose solutions require the coordinated input of several disciplines. Accordingly, a research team consisting of a plant physiologist, cytogeneticist, range scientist, and grass breeder has been assembled.

Breeding for Drought

Genetic progress in any breeding program is dependent on the amount of genetic variation in the population from which selections are made and on the heritability or degree to which the desired traits are transmitted to the progenies of selected plants. It is also vital that we accurately identify and select superior plants from large populations.

Results from range reseeding might have been enhanced by the use of improved strains of grasses

Ample genetic variation appears to be available in crested wheatgrass to permit meaningful progress in increasing drought resistance. Progenies from 150 clonal lines of crested wheatgrass, which had been selected from a 20,000-plant source nursery, were screened for germination under drought stress. Laboratory procedures used in screening trials are described elsewhere in this issue of *Utah Science* (p 11). Germination, averaged over two levels of controlled drought stress, ranged from 11 to 89 percent. Of the total variation among progeny lines, 56 percent was due to genetic factors, indicating that selection for better germination under drought should be effective.

The same crested wheatgrass progeny lines were screened for recovery after severe drought stress in a series of trials in a controlled environment chamber. Responses ranged from complete mortality in some lines to excellent recovery in others. Heritability, or the portion of the total variation among lines due to genetic causes, was well over 50 percent in most trials. As with germination under drought stress, it was evident that selection for seedling recovery after drought stress would be effective.

Over 400 crested wheatgrass lines (including those previously screened in the laboratory) were evaluated for agronomic performance and for seedling emergence and vigor under drought stress at 3 field locations in Utah and Idaho. One planting was located on an extremely dry site at Curlew Valley in northwestern Utah (Figure 1). Results were more variable than those from laboratory trials; however, significant differences were detected among lines in their response to drought during seedling establishment. Slightly over 45 percent of the variation among lines was due to genetic factors.

Figure 1. Crested wheatgrass progeny test for seedling establishment under drought stress in northwestern Utah.

Parental clones have been selected on the basis of their progeny performance in laboratory trials and under drought conditions in the field. These clones are being included in a hybridization and selection program to produce varieties that are easier to establish and persist better under drought conditions than previously used crested wheatgrass varieties. Similar research programs are being conducted with Russian wildrye and with promising interspecific hybrids.

New Species Through Hybridization

Interspecific hybridization can be a valuable breeding tool for 1) transferring traits such as disease resistance from one species to another and 2) combining the desirable characteristics of two or more species into a new species.

The world's largest collection of *Agropyron* (wheatgrasses) and *Elymus* (wild ryegrasses) has been assembled at Logan. In addition, over 100 potentially useful new species have been developed through interspecific hybridization. Several of these hybrids have shown sufficient promise to merit testing and breeding work; however, sterility problems are often encountered.

An interspecific hybrid is often healthy and vigorous, but it usually produces few, if any, seeds. Fertility can be achieved by 1) backcrossing to one of the parental species or 2) doubling the chromosome number of the hybrid plant through treatment with the drug colchicine. The latter method has been used with some success at Logan to develop fertile hybrids. However, fertility often declines rapidly in succeeding generations. Figure 2 shows the fertility trends of a group of hybrid derivatives after colchicine treatment. In the first generation after doubling, the chromosome number of a sterile hybrid (Colchicine generation), seed set was over 26 seeds per spike. Fertility declined thereafter, however, particularly in the hybrids with 56 chromosomes.[2] We are presently studying the reasons for this decline and possible ways to reverse the trend.

The most promising new species in our research program appears to be the hybrid between *Agropyron repens* (quackgrass) and *Apropyron spicatum* (bluebunch wheatgrass). Initially, this hybrid population was cytologically unstable with variable chromosome numbers and low seed set. In general, the plants were weak with poor agronomic qualities, and appeared to have little potential of becoming a useful breeding population.[3] Now, 6 generations later, the hybrid has improved substantially. Fertility is equivalent to that of the parental species and characteristics of both parental species are represented in the population.

We are optimistic that we can combine the drought resistance, forage quality, and bunch habit of bluebunch wheatgrass with the general vigor and growth potential of quackgrass. Observations from a droughty site in northwestern Utah indicate that the hybrid is more drought resistant than we had thought. Plants established during the spring of 1975 displayed more growth than crested wheatgrass during the hot, dry, summer period. Additional screening in the laboratory and field in 1978 will further exploit the population's genetic potentials for drought resistance.

Genetic variation in this population will also permit us to breed for strains that are adapted to more humid conditions. Such strains could be used to replace intermediate wheatgrass (*Agropyron intermedium*) in range seedings, or combined with a legume such as alfalfa under irrigation.

Types have also been selected with the leafy appearance and general plant type of bluebunch wheatgrass and robustness and rhizome habit of quackgrass. We are using these selections to develop strains for revegetating areas disturbed by surface mining and soil stabilization on droughty sites. We are establishing breeding nurseries in cooperation with the US Forest Service on surface mining areas and other problem sites. Selections from these nurseries will form the parentage for new varieties.

Range improvement through plant breeding is a promising avenue for meeting future demands on western rangelands. Our goal is to fully exploit this previously untapped area of research.

Crested Wheatgrass Source Nursery

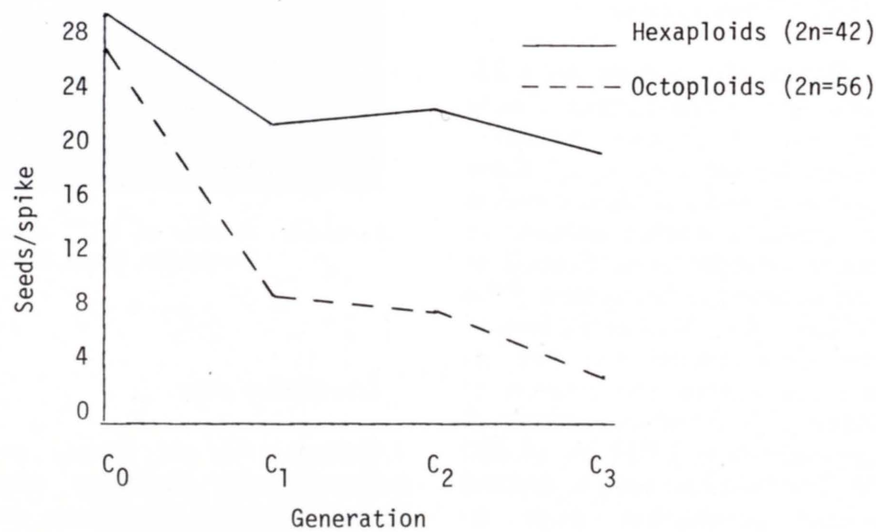

Figure 2. Mean seed set of 5 hexaploid and 4 octoploid interspecific hybrid populations in each of 4 generations after chromosome doubling.

[1] National Science Foundation. 1977. Back to the range. Mosaic Vol 8. 6 pp.

[2] Asay, K. H. and D. R. Dewey. 1976. Fertility of 17 colchicine-induced perennial Triticeae amphiploids through four generations. Crop Sci. 16:508-513.

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Kay H. Asay is Research Geneticist, USDA-ARS, Crops Research Laboratory, USU.

Douglas A. Johnson is Plant Physiologist, USDA-ARS, Crops Research Laboratory, USU.

Douglas R. Dewey is Research Geneticist, USDA-ARS, Crops Research Laboratory, USU.

Characteristics of an Old Stand of Dryland Alfalfa

M. D. Rumbaugh

The name "alfalfa," generally includes two species, *Medicago sativa* and *M. falcata,* and their hybrids, evolved as important legume components of semiarid rangelands in Asia. Some scientists have therefore explored the possibility of alfalfa providing dryland pasturage in the Intermountain area. Difficulty of establishment and doubts about its persistence, however, prevented wide spread usage of alfalfa for this purpose.

Recent observations on a 23-year-old experiment near Snowville, Utah, have stimulated research that may offset those problems and aid plant breeders in breeding alfalfas adapted to range environments. Seeded in 1954 under the supervision of the USDA's Dr. Marion Pedersen, the experimental site has an average annual precipitation of 28 cm (11 in) and an elevation of approximately 1,417 m (4,650 ft). The field had been in dryland wheat production prior to Pedersen's seeding of alfalfa at 6.7 kg/ha (6 lb/ac) on May 12, 1954. Eight types of alfalfa were included, each in a plot 12.2 m (40 ft) wide and extending 76 m (250 ft) along the contour of the gently sloping hillside. Grasses were not included in the experiment, but crested wheatgrass was seeded in the fields adjacent to the alfalfa plot.

Figure 1. A view in 1977 of an alfalfa experiment seeded near Snowville, Utah, in 1954.

The alfalfas were:

Grimm. An old variety introduced from Germany into Carver County, Minnesota, in 1857 by Wendelin Grimm. It underwent further natural selection in that climate and is very winterhardy. Grimm produces forage of high quality and usually yields well unless attacked by bacterial wilt disease.

Ladak. This variety was brought to the United States from northern India in 1910 by the Department of Agriculture. It also is very winterhardy, and is less susceptible to bacterial wilt than Grimm. Ladak plants are shorter and less erect than those of many other varieties. It yields exceptionally well in the first cutting, but is inferior to most varieties in the second cutting on sites where ample moisture is available. Ladak commonly becomes dormant during prolonged summer droughts and in early fall.

Nomad. This alfalfa was developed in 1941 from plants that had persisted in growing on a dryland farm in Klamath County, Oregon. Nomad is a hardy variety frequently suggested for dryland pasture and range use. Some plants have well developed underground stems (rhizomes) that facilitate their spreading under favorable conditions. Nomad is susceptible to bacterial wilt.

Ranger. This variety was the first bacterial wilt resistant alfalfa adapted to the northern United States. It became available in 1941, and has been used extensively since then. Ranger is an excellent seed and forage producer where it is adapted.

Rhizoma. Bred at the University of British Columbia, Vancouver, Canada, from a cross between a yellow-flowered alfalfa and Grimm, Rhizoma is characterized by an extensive underground development of crown branches when it grows in the northern latitudes to which it is best adapted. This variety is very winterhardy but is also very susceptible to bacterial wilt.

Sevelra. A selection from a dryland stand of alfalfa that had been growing on the Seven-L Ranch in southern Idaho since 1918 gave us Sevelra. This alfala is believed to be somewhat less hardy than Ranger, but is quite drought resistant. Some plants show considerable rhizome development under dryland conditions.

Utah Common. Seed of this alfalfa was produced in Utah and is adapted to the environment of the Intermountain area.

M. falcata. A yellow-flowered alfalfa known to be very winterhardy and tolerant of drought. Seed for the strain planted in Snowville was obtained from the vicinity of Coal Spring, South Dakota. It is susceptible to bacterial wilt.

Post-Planting Observations

Early records describing the results of the experiment are not very detailed, but we do have forage yield data (Table 1). In 1956 the yield level was quite high, averaging 3.90 t of dry forage per ha (1.74 ton/ac). The varieties seemed to differ little, although Sevelra produced the most hay and Nomad the least. When the field was examined in June 1960, the plants were judged too short to cut. More favorable precipitation in subsequent months led to approximately 3/4 t of hay being harvested per ha (1/3 ton/ac) in 1961.

No other harvests were made until 1977. The alfalfa was grazed intensively in the spring of that year, with the cattle being removed prior to May 18. Forage samples clipped on July 6, indicated a yield of approximately 0.47 t (0.21 ton) of alfalfa and 0.43 t (0.19 ton) of Russian thistle per ha (ac). Again, there were few differences among the varieties, and the exceptionally dry 1976-1977 season had greatly restricted the growth of the crop. The adjacent field of crested wheatgrass provided 0.38 t of grass forage per ha (0.17 ton/ac) or 81 percent as much as the alfalfa alone. It might be wondered whether a grass-plus-legume combination would have maximized the yield potential of the site.

The Russian thistle was an apparently recent invader. Seven years after the alfalfa had been seeded (1961) observers noted "no invasion of weeds." A later, undated comment stated, "Cheatgrass in space not occupied by alfalfa." On June 17, 1966, it was noted that conditions were so dry that cheatgrass had not started growth. No other observations were made until 1977, at which time there was almost no cheatgrass present and Russian thistle was uniformly and heavily distributed throughout the experimental plots.

Table 1. Oven-dry forage yields in a test seeded at Snowville, Utah, in 1954

	Forage Yield (metric tons/hectare)					
	1956	1961	1977			
Variety	Alfalfa	Alfalfa	Alfalfa	Russian Thistle	Crested Wheat-grass	Total
Grimm	3.90	0.49	0.45	0.65	---	1.12
Ladak	3.83	0.76	0.47	0.27	---	0.74
Nomad	3.41	0.78	0.40	0.45	---	0.85
Ranger	4.01	0.83	0.56	0.47	---	1.01
Rhizoma	3.59	0.56	0.34	0.54	---	0.87
Sevelra	4.06	0.92	0.54	0.31	---	0.83
Utah Common	3.99	---	0.43	0.56	---	0.99
M. falcata	---	0.76	0.47	0.13	---	0.61
Crested Wheatgrass	---	---	---	---	0.38	---
Mean	3.90	0.74	0.47	0.43	0.38	0.87

The thistle may have invaded the alfalfa as the legume stand declined due to moisture stress. On May 12, 1959, however, the stand of *M. alcata* had been described as "poorest stand" and "stand thin but O.K." At the same time, plots of Nomad and Rhizoma were considered to be fair, while densities of plants of the other alfalfas were rated as "good." Similar comments were noted in 1960, 1961, and 1966 without any thistle invasion occurring.

During July, 1977, every mature alfalfa plant in the experiment was counted. The stand was regarded as being in excellent condition for that environment. The average equivalent was of 25,686 mature alfalfa plants per ha (10,395/ac) (Table 2). *Medicago falcata,* which originally had the poorest stand, now had more plants than any other variety except Nomad.

As the mature plants were being counted, I noticed many developing alfalfa seedlings that were presumed to have originated from seed set in 1976. Ten samples consisting of 1.07 m (42 in) diameter circles were examined per population on July 7, 1977, and again on September 20, 1977. A surprisingly high number of seedlings was observed (Table 2). Although summer mortality was severe, the average of 22,375 seedlings per ha (9,055/ac) should provide sufficient survivors to maintain stand density. I believe this may be an important mechanism in sustaining the productivity of range alfalfa plantings. Appropriate grazing management would be essential to allow the alfalfa to flower and set seed, and to permit seedling establishment.

The seedlings were remarkably vigorous in 1977 despite the limited rainfall available for plant growth during that year's drought (Figure 2). The Nomad plot contained fewer seedlings than did the plots of the other varieties. This may reflect the amount of seed produced rather than seedling vigor. The numbers of seeds per hectare and equivalents in kilograms of seed per hectare were calculated in 1977 (Table 3). Nomad produced less seed than any of the other 7 alfalfas. *Medicago falcata* was a poor seed producer compared to Sevelra and Utah Common. Seedling survival during the summer varied from a high of 15.6 percent for Grimm to a low of 3.2 percent for *M. falcata*. Both the amount of seed produced and seedling survival rates are important when evaluating a species for rangeland planting.

Table 2. Age characteristics of the Snowville, Utah, alfalfa seeded in 1954 and counted in 1977

	Plant number per hectare (thousands)			
	Seedlings		Mature	
Variety	July 7	Sept. 20	Young	Old
Grimm	214.8	33.6	0	17.2
Ladak	337.9	12.8	0	26.7
Nomad	36.9	3.4	3.4	34.7
Ranger	200.3	13.4	1.3	19.1
Rhizoma	106.3	14.5	13.1	16.9
Sevelra	318.8	21.3	1.9	24.4
Utah Common	228.2	79.4	2.0	12.2
M. falcata	137.6	4.5	2.9	29.7
Mean	197.6	22.4	3.1	22.6

Figure 2. A dryland alfalfa seedling growing in July, 1977, at Snowville, Utah.

In 1977, I also dug up a representative number of the older alfalfa crowns and examined them to determine their size, approximate age, and health status. Some of these crowns were very large, often exceeding 20 cm (8 in) in diameter. I believe such plants were survivors from the 1954 planting. All original crowns (regardless of size) were badly afflicted with root and crown rot. Most had sectors of healthy conductive tissue along the peripheral margin of the crown, however, and therefore remained productive.

Two types of smaller crowns could be distinguished. One had evidently arisen from existing plants by asexual vegetative processes. These plants were difficult to separate visually from older crowns and are therefore grouped as old plants (Table 2). The other type arose from seedlings and could be distinguished by a light-tan root color and their uniformly shaped crowns. Both reproductive mechanisms contribute in important ways to the sustained productivity of the planting. The three classes of mature plants are illustrated in Figure 3.

Table 3. Average numbers and estimated kilograms per hectare of alfalfa seed in the 1954 Snowville test. Harvested September 20, 1977

	Alfalfa seeds per hectare	
Variety	**Number (thousands)**	**Kilograms**
Grimm	2,202.8	5.0
Ladak	2,735.4	6.2
Nomad	496.7	1.1
Ranger	2,179.3	4.9
Rhizoma	2,459.0	5.6
Sevelra	3,597.9	8.2
Utah Common	3,554.3	8.1
M. falcata	1,141.1	2.6
Mean	2,016.0	4.6

Figure 3. Three types of crowns of mature alfalfa plants in the Snowville, Utah, experiment.

The young seedling plants could readily be separated from the older plants in all varieties except Rhizoma. Rhizoma crowns are typically less compact and dense than those of the other varieties. They tend to be torn apart during digging and we may have misclassified some of these parts of crowns as young plants. Nevertheless, there were very marked differences among the varieties in ability to reproduce by both vegetative propagation and by seed.

The Snowville site will be studied intensively in coming years to clarify how alfalfa plants respond to stress in a challenging environment. The site also will provide materials for future breeding programs. If natural selection for drought tolerance has occurred, the resultant germplasm will be valuable to those trying to develop alfalfa for Intermountain rangelands.

Melvin D. Rumbaugh is Federal Collaborator, ARS, USU.

Science Short

Virus—Virus—Who Has the Virus?

With dismal regularity these days, the answer often is a mournful, "I think I do." But with viruses being by nature furtively pervasive, diversity incarnate, *and* hard to identify, an unequivocal answer can be virtually impossible.

Some USU researchers, led by Rex S. Spendlove (Professor of Biology), have, however, successfully simplified the detective work involved in tracking at least one kind of virus. Their easy-to-use fluorescent virus precipitin test (FVPT) has proved remarkably rapid and reliable in revealing the presence of certain diarrhea-causing reoviruses.

Originally perfected to facilitate the diagnosis and eventual treatment of neonatal calf diarrhea, the FVPT subsequently gave valid results when applied in comparable cases involving human infants. The conclusion was that one form of gastroenteritis in calves and human infants is caused by apparently closely related viruses that can be identified with the FVPT.

Recent investigations (in which the human virus induced infection not only in calves, but also in young pigs) further proved that cross-species infection is possible. That potential indicates a need for extreme caution around establishments where an individual might work with unwell calves or pigs and then come in contact with a human infant. The aggressively infectious nature of the *human* virus has been described indirectly in hospital reports of virus-caused gastroenteritis whipping through nursery populations of infants.

The USU researchers are currently developing a more sensitive test that will not require the use of a fluorescence microscope. When the test is perfected it will be possible for a veterinarian (while at the farm) to determine the cause of most cases of calf scours if they are virus-induced.

Screening for Drought Resistance in Range Plants

Douglas A. Johnson and Kay H. Asay

Approximately one-third of the United States is classed as arid or semiarid (Gardner and Meyers 1967). Most of this area consists of western rangelands that experience drought during at least part of each growing season. Drought stress is one of the most common environmental limitations to forage production on United States western rangelands. Consequently, maximum forage production on these rangelands hinges on the ability of range plants to withstand drought stress. Because seedling establishment is also a limiting characteristic for seeding western rangelands, forage breeding programs for western ranges must include screening procedures to evaluate seedling drought resistance.

To date, no plant characteristics have proved to be adequate quantitative guides to drought resistance. As a result, evaluations require that plant materials be exposed to drought conditions. Because field trials require large expenditures of time and money, and fluctuating weather conditions make field comparisons among different years extremely difficult, reliable laboratory screening techniques are required.

Personnel of the USDA Agricultural Research Service's Forage and Range Research Program at Utah State University are developing systematic screening procedures for the improvement of drought resistance in promising forage species.

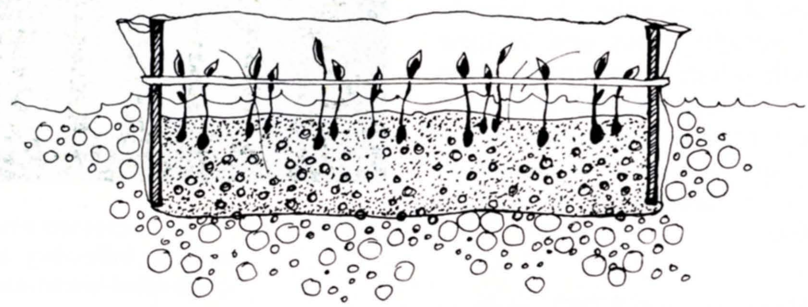

Figure 1. Plastic container with two soil-filled germination vessels used for evaluating seedling emergence under drought.

Emergence Under Drought Stress

Several techniques have been used by plant breeders to assess seedling emergence under drought stress. In one procedure, the germination of seeds is measured on a blotter containing a known concentration of osmotic solution (such as salt, sugar, or polyethylene glycol). By varying the strength of the osmotic solution, a wide range of drought (soil water availability) conditions can be simulated. However, problems have been encountered with this procedure because the seed is in direct contact with the osmotic solution and the blotter environment may not be comparable to the field situation.

We have modified a procedure from Kaufmann (1969). This technique avoids direct contact between seed and osmotic solution and uses soil as a germination medium. The system (Figure 1) utilizes a plastic container filled with an osmotic solution and 2 soil-filled germination trays, each wrapped with a membrane. Desired soil water conditions are achieved by adjusting the concentration of the osmotic solution. After a predefined soil water level is achieved, 100 seeds are uniformly planted in the vessels and emergence counts are taken after 7 days. This procedure allows us to evaluate emergence in 160 plant breeding lines in 11 days.

We've used this technique in evaluating drought emergence potentials of over 400 lines of crested wheatgrass. In addition, breeding lines of alfalfa and Russian wildrye will be screened with this procedure.

Recovery After Drought Stress

But what if drought occurs during the early seedling stage? Plant survival then depends on the ability of the seedling to tolerate the drought stress and resume growth when precipitation does arrive. To examine this important aspect of seedling recovery, we are using a technique similar to the one developed by Wright (1964).

We start nearly 3,000 seedlings per experiment in a greenhouse. At 3 weeks of age, the seedlings are transferred to a growth chamber that allows us to precisely control light, temperature, and relative humidity. The growth chamber is programmed for an environment that closely simulates early-summer range conditions. The seedlings are given time to become accustomed to their new environment, and then water is withheld for 17 days. The seedlings next are returned to the greenhouse and watered. After 3 weeks of regular waterings, the seedlings are rated for recovery (Figure 2).

Over 160 lines of crested wheatgrass have been evaluated using this procedure. These same crested wheatgrass lines have been planted on a low-rainfall range site in northwestern Utah. Field observations will be compared with the results of our laboratory screening procedures. Research is also being done to adapt this technique for screening breeding lines of Russian wildrye and dryland alfalfa.

Figure 2. Trays of crested wheatgrass seedlings ready for recovery ratings following a 2½ week drought exposure in a controlled-environment chamber.

Maintenance of Plant Turgor

Another possible way to judge drought resistance in plants involves what is called plant turgor (Johnson and Brown 1977). Turgor refers to the force inside a plant cell that keeps cell walls from collapsing. Without cell turgor, a plant can't grow. Consequently, a plant that can maintain its turgor during drought stress is more likely to survive and grow again than is a plant that loses turgor and wilts.

Plant turgor is analyzed using a technique that involves freezing and thawing of the leaf tissue. This technique has been used to determine turgor differences between plants with known drought resistance. Corn (*Zea mays*), for example, was not able to maintain turgor over a wide range of drought conditions. In contrast, crested wheatgrass (*Agropyron desertorum*) did keep its turgor high over a wide range of drought conditions (Figure 3). This procedure also enables us to distinguish turgor differences between closely related *Agropyron* hybrids, which suggests its possible usefulness in screening breeding lines for superior drought resistance.

The Future

As expenses associated with the feedlot industry continue to rise and acreages previously used for forages are diverted to other uses, more demands will be made on United States western ranges. Only the best available forage plants and range management techniques can insure the desired optimum returns from these rangelands. That means we must develop forage plants specifically geared for use on western rangelands and learn how to combine their growth cycles with livestock grazing pressures. Our plant screening work is a basic step in that direction.

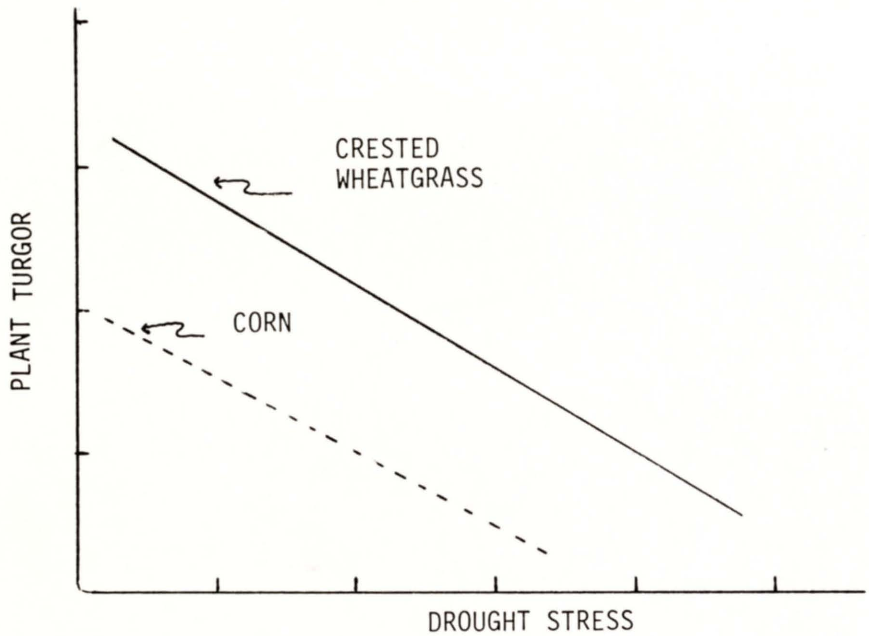

Figure 3. Plant turgor response of drought-sensitive corn and drought-resistant crested wheatgrass under increasing drought stress.

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Douglas A. Johnson is Plant Physiologist, USDA-ARS, Crops Research Laboratory, USU.

Kay H. Asay is Research Geneticist, USDA-ARS, Crops Research Laboratory, USU.

Science Short

Can Sheep Grazing Help Deer Survive Winter?

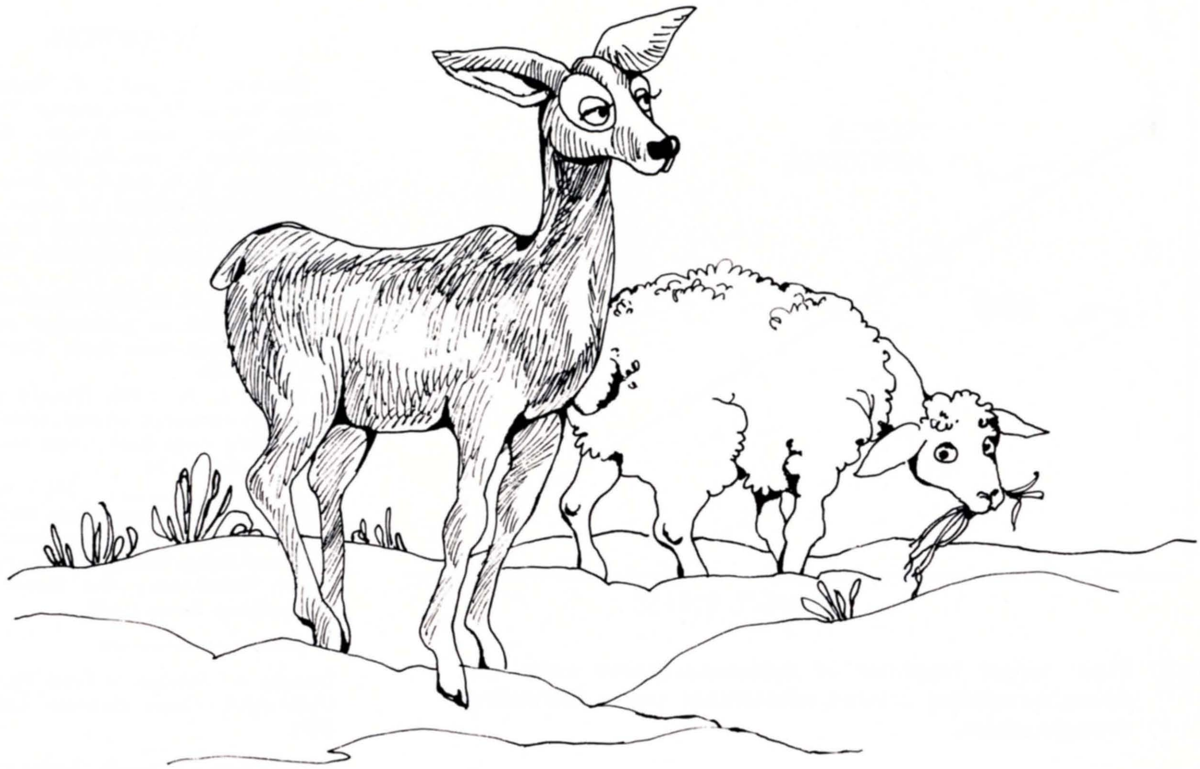
Ann Schimpf

Utah State University researchers are hoping that grazing sheep can enhance the quality of Utah's limited deer winter range. If they're successful, both sheepmen and hunters could benefit.

Wildlife resource personnel and hunters have long lamented the deficit of deer winter range in Utah. The problem is compounded by the fact that deer winter range is often used for spring and summer sheep grazing. If poorly controlled, grazing by domestic sheep can effectively ruin an area for deer winter range, but well-controlled sheep grazing is another thing. Recent research has indicated that livestock can be used to manipulate winter range vegetation to effectively increase quantities of available browse.

The research was conducted at Hardware Ranch, Cache County, Utah, on an area similar in physiography and vegetation to much of the northern Utah and southern Idaho deer winter range. The area has southerly and southeasterly slopes supporting a mixed shrub-forb-grass plant community codominated by bitterbrush (*Purshia tridentata*) and big sagebrush (*Artemesia tridentata*). Annual precipitation in the area varies from 46 to 66 cm (18.4 to 26.5 in), with the major portion falling as snow.

Two adjacent pastures were fenced. One was grazed by sheep, the other was not. Both were grazed by deer the following winter. Point frame sampling was



used as the technique to determine species composition in the pastures. Routine ocular observations of the captive grazing deer determined dietary preferences of the animals.

The two 2.4 ha (6 ac) pastures were grazed by a flock of 20 range ewes and their lambs over a 20-day period in late May and early June. The grazing impact was measured as 150 sheep-days per ha (60 per ac). The 5 deer were placed in the pastures for two 6-week periods extending from early November to mid-December and from mid-March to late April. Total accumulative deer grazing use was 100 deer-days per ha (40 per ac), an amount considered typical of northern Utah winter ranges.

The results support the general hypothesis that controlled spring sheep grazing can increase the proportion of browse (current growth bitterbrush) available to deer the ensuing winter.

Big sagebrush, bitterbrush, and bluegrasses were the most abundant plant species growing on the study areas. Spring-time sheep grazing had the effect of increasing the proportion of current year's bitterbrush. Current year's parts comprised 24 percent of bitterbrush shrubs in the sheep-deer pastures and only 14 percent in the deer-only pasture.

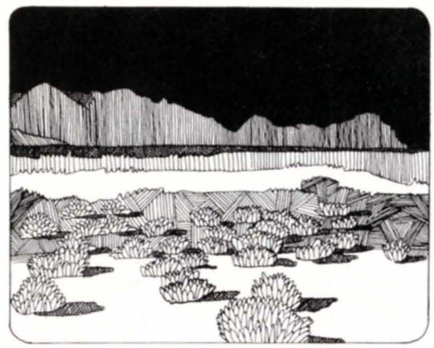
In addition to the effect of sheep grazing on available browse, the study also determined the dietary preferences of the wintering deer. The deer in the sheep-deer pasture ate a greater quantity of grasses and a higher total of herbaceous species. This difference can probably be attributed to the fact that grazing by sheep removes dead stalks of herbaceous material with the net result of making forbs, low-growing shrubs, and new green material more accessible.

A further observation on the dietary preferences of the deer revealed that during the first half of winter shrubs were generally the most important part of the diet. With the melt of snow in late winter, dietary shrubs decreased in percentage usage while use of herbaceous species increased.

The study has important implications for management of Utah's rangelands. The questions it raises on the nutritional value of deer's diets suggest further research efforts, research on questions such as: Do deer "select" foods of high nutritional value? How does the nutritional value of browse in ungrazed range compare with grazed range?

Ann Schimpf is Copy Editor, Agricultural Experiment Station Publications, USU.

Sagebrush Symposium in April



A Sagebrush Ecosystem Symposium will be held at USU on April 27 and 28 at the end of Conservation Week. Sponsored by the College of Natural Resources and the Natural Resources Alumni Association, the symposium's meetings will be held in the University Center Auditorium.

Although the sagebrush ecosystem is widespread throughout the western United States, it has not been subject to large scale research. Interest is high on the subject, however, and increasing work in the type—for instance in preparing environmental impact statements—has identified many of the existing voids within the information pool.

The purpose of the April Symposium is to synthesize into state-of-the-art papers as much of the current available knowledge on the sagebrush ecosystem as possible. Papers will cover 3 general aspects: 1) a general introduction to sagebrush ecosystems, 2) manipulation techniques, and 3) use and management. Emphasis will be placed on the *Artemisia tridentata* mix, including *Artemisia nova* and *Artemisia arbuscula*, which have a shrub-like woody growth form.

Information regarding registration, fees, and copies of the Symposium Proceedings can be had by contacting G. Fred Gifford, College of Natural Resources, UMC 52, Utah State University, Logan, UT 84322.

River-clogging Salt—A Search for Sources

Lois M. Cox

Photo by G. F. Gifford

The Colorado River has always carried salt (dissolved solids). In pre-white-man days, in fact, its estimated load was 600 to 700 ppm at the lower reaches. Today, those areas average 850 ppm, with projections calling for 1300 ppm by the year 2000.

But somehow the salt load of the Colorado seems less crucial to your existence than prices at the supermarket? You may be right—but only in the short run. Anyone who habitually wants food on a regular basis has reason for concern about the Colorado's salt. Why? Because the Colorado River happens to be the sine qua non of thousands of acres of cropland in the southwestern United States and in Mexico. And salty irrigation water can quickly transform productive farms into marginal operations. Hence there is considerable research interest in the Colorado's salt load.

In general, removing salt from a river has proved to be more difficult than preventing its entrance in the first place. Researchers have therefore been concentrating on identifing the sources of the Colorado's dissolved solids.

The current consensus (guesstimate) is that about 1/3 of the river's total salt load comes from irrigation return flows. Another third can be traced to natural sources such as salt wells and springs, and evaporative concentration. The final third is believed to come from diffuse sources scattered over the immense acreages of the Colorado River Basin's wildlands. The salt from these diffuse sources enters the River via bank and stream-bottom erosion, seepage, and/or overland flows (water moving over the soil surface).

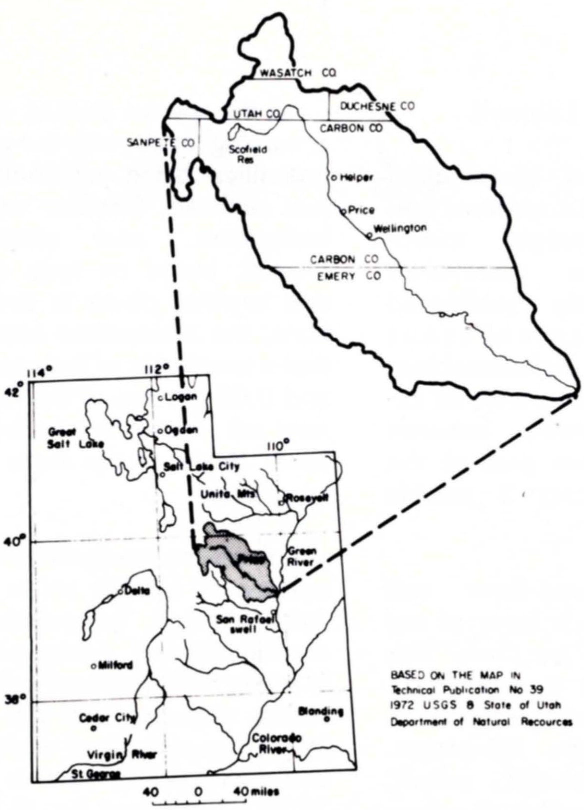
The research goal, of course, is to more precisely identify the sources and then devise ways to contain or modify their salt output.

A Piece of the Whole

Since a study of the entire Colorado basin would be impracticable, the best approach has been to work on subbasin units. In the spring of 1974, therefore, a USU research team (G. F. Gifford, Associate Professor of Range Science, R. H. Hawkins, Associate Professor of Forestry and Outdoor Recreation, J. J. Jurinak, Professor of Soil Science and Biometeorology and several graduate students) turned its attention to the Price River Basin of Utah.

The Price River seemed a good choice for study for several reasons, not the least of which is its being ranked as a major source of salinity as it feeds into the Green, which feeds the Colorado. Then too, the climate and vegetation of the Price River Basin are typical of the Upper Colorado River Basin. Precipitation in the Price Basin varies with altitude, topography, and relation to the prevailing west-to-east storm track. About 70 percent of the Basin, however, qualifies as semiarid (203-254 mm or 8-10 in of precipitation per year).

The Price River itself flows for 158 km (95 mi) in a southeasterly



The Price River Basin Study Area.

direction. It is used for irrigation in the central part of the basin, but this use affects only about 2 percent of the land. Most of the rest is dedicated to raising cattle and sheep. The major industry is underground coal mining.

But when it comes to salt and sediment production, past events can be as important as present usage. Which is certainly true for the Price River Basin. The geological history of the Basin tracks the deposition of a distinctive pattern of limestone, sandstone, and shale (Figure 1). The extensive Mancos Shale layers, which are of marine origin, have an exceptionally high potential for salt production. In other words, their mineral components are readily dissolved and transported by water.

To the researchers, that made the Mancos Shale a prime candidate for salt source "honors." There *were* other possibilities, however. And even if the Mancos Shale proved to be the main culprit, its released salts were expected to take circuitous routes to the Price River.

In looking for answers to source and route questions, the research effort was divided into 4 projects: 1) mechanisms of surface hydrology, salt pickup, and microchannel erosion; 2) native vegetation as a possible salt source; 3) soil chemistry implications; and 4) effects of range improvement practices. Procedural and analytical details of the projects are available in the October 1977 Final Report, *Effects of Land Processes on the Salinity of the Upper Colorado River Basin* (available from G. F. Gifford, Department of Range Science, USU).

What Was Learned

Three years of investigation relative to surface conditions and responses of test-plot micro-watersheds to simulated rainstorms mostly reaffirmed nature's cantankerous heterogeneity. Relationships, reactions, and results were all exasperatingly variable between plots. In fact, this part of the study yielded only 3 reliable generalities.

First, overland-flow salt pickups involved a layer of soil just 2.5 mm (.1 in) thick. This layer underwent a quick (20-minute) salt-depletion reaction to rainfall. After the 20-minute, relatively high-in-salt runoff, salinity values receded to a base level.

Second, storms that cause such overland salt runoffs initiate less than 1 percent of the Basin's total salt production. The microchannel (small gully) contribution probably averages about 2.5 percent of the total. And third, adjacent areas that look identical may respond quite differently to rainfall in terms of their infiltration rates, salt production, and runoff volumes.

Among the plant species tested for their salt production were: (mat saltbush (*Atriplex corrugata*), halogeton (*Halogeton glomeratus*), Gardner saltbush (*Atriplex gardneri*), salt cedar (*Tamarix pentendra*), shadscale (*Atriplex confertifolia*), greasewood (*Sarcobatus vermiculatus*), and four-wing saltbush (*Atriplex canescens*). The procedures involved analyzing both the water from simulated rainfall that ran off of stems and leaves, and the on-ground litter from each species.

All the species yielded salt, but at varying levels, with the greatest quantities being obtained from mat saltbush, Gardner saltbush, halogeton, and shadscale. Overall, based on tests of litter and in-place plants in two locations, the researchers concluded that a maximum of between 0.01 and 0.02 percent of the total annual salt production in the Price River Basin comes from native vegetation.

Laboratory manipulations were needed to identify some of the water-affected interrelationships among mineral components of Mancos Shale derived soils. The results indicated that 2.5 cm (1 in) of the surface of such a soil could potentially release about 7258 kg salt per ha (3.2 tons salt/ac), assuming all the salt was eventually leached from the soil. The salinity of Mancos Shale soils increases with depth, however, so that subsoils could be expected to release much more substantial amounts of salt if they were penetrated by moisture.

Various range improvement practices were tested for their effects on annual forage production, quantity of ground cover, and soil-profile salt concentrations. The treatments included gully plugs, pitting, chaining, plowing, and contour furrowing.

The results of the tests shifted disconcertingly, depending on original cover, soil type, and soil texture. Erosion control, whether achieved with gully plugs or contour furrows, *should* mean a simultaneous reduction in salt flow. Regrettably, however, the research results were less than unequivocal on this point. Additionally, gully plugs have a potential for encouraging subsurface water movement, which can equate with enhanced salt outflow because of the high salt content at the subsoil level. Plant cover responses to the tested range improvement procedures were variable, with annual production depending on soil characteristics.

In essence, applying today's range improvement practices to either sagebrush or pinyon-juniper vegetation types would not be expected to affect the land's salt production. The same practices applied to sites with especially high salt-production potentials (such as Mancos Shale lands) would probably give mixed (and unpredictable) results relative to salt production.

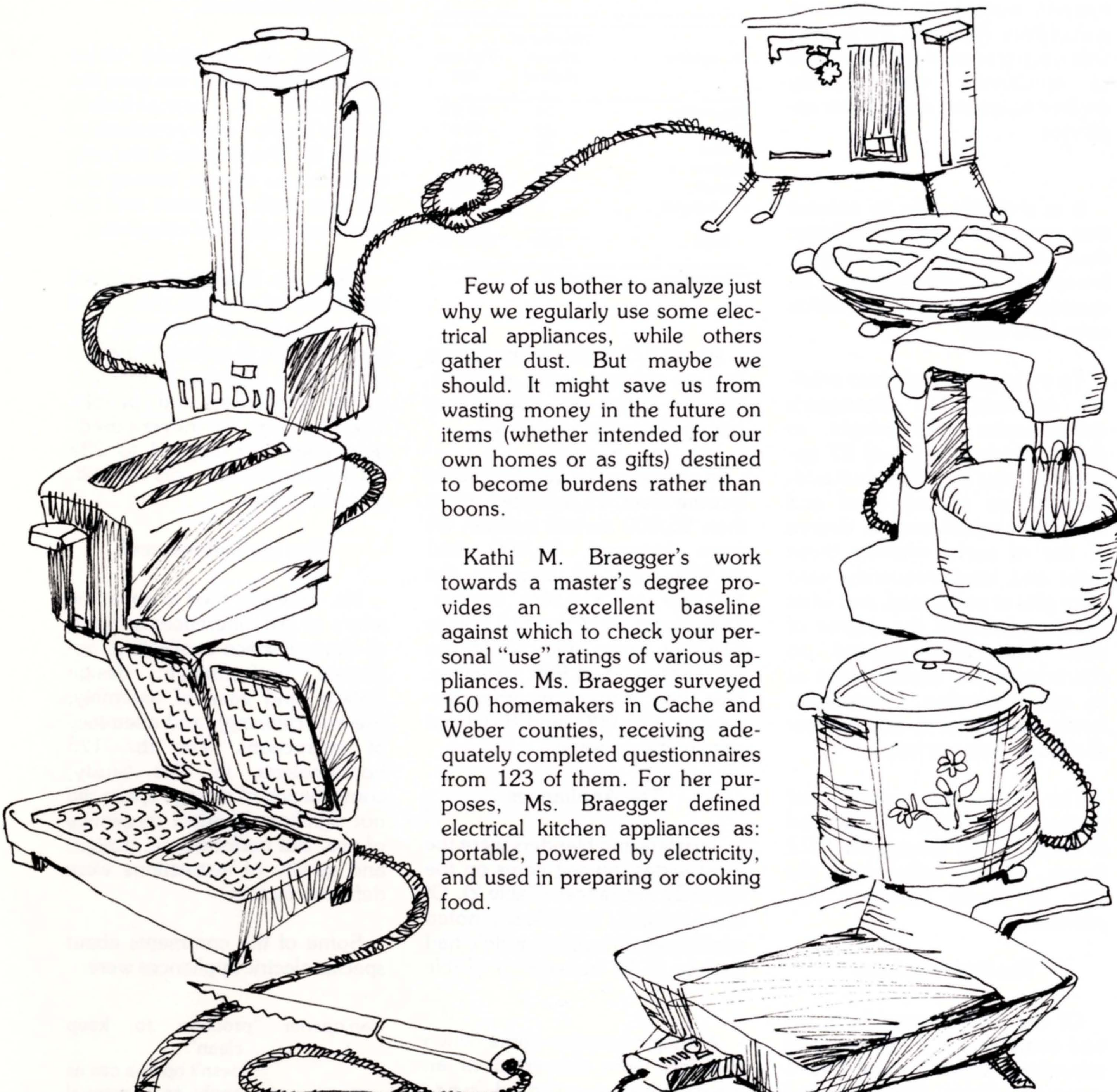
Where We Are

In summary then, results of the Price River Basin work indicate that salt contributions to the Price River system from vegetation, overland flow, and microchannel erosion on marine shale soils amount to perhaps 3.5 percent of the annual total. This small percentage clearly implies that other diffuse sources must be having a major impact. Such sources may well include agricultural activities and subsurface groundwater flow patterns in the basin. Any measurable effects these two possible contributors to basin salt movements are having remain to be defined and quantified. The salt-pickup effects of major channel processes such as the flow of water in a channel and its associated erosion of the bottom and sides, and seepage into the channels due to subsurface flows are also still unknown.

Lois M. Cox is Science Writer, Agricultural Experiment Station Publications, USU.

Electrical Appliances: Burden or Boon?

Jane L. McCullough



Few of us bother to analyze just why we regularly use some electrical appliances, while others gather dust. But maybe we should. It might save us from wasting money in the future on items (whether intended for our own homes or as gifts) destined to become burdens rather than boons.

Kathi M. Braegger's work towards a master's degree provides an excellent baseline against which to check your personal "use" ratings of various appliances. Ms. Braegger surveyed 160 homemakers in Cache and Weber counties, receiving adequately completed questionnaires from 123 of them. For her purposes, Ms. Braegger defined electrical kitchen appliances as: portable, powered by electricity, and used in preparing or cooking food.

Such appliances established their beachhead in American homes in the early 1900s. But they didn't begin a full-fledged invasion until after 1930, when about 80 percent of all rural and urban homes were equipped with electricity. By 1936, most American homemakers were happily familiar with electric toasters, waffle irons, mixers, and percolators. By 1970, the market was over-saturated with a variety of appliances, with virtually endless styles and designs per appliance.

It is probably safe to assume that some of the array are better than others at enhancing a homemaker's efficiency. The questions, of course, are which ones, and why?

To try to gain insight into possible answers, Ms. Braegger's questionnaire first sought to define which of a list of 27 appliances (plus any individual additions) were owned, total and average numbers owned, degree of use of each, whether those most and least frequently used were gifts or purchased, and what factors influenced the degree of use. She also wanted to characterize her homemakers as to age, education, occupation, family income level, and number of children living at home.

The questions asked and methods of analysis are described in detail in Ms. Braegger's 1977 thesis: *Factors Influencing the Use of Small Electrical Appliances*.

The Homemakers

Of the 123 homemakers, 39 had completed 7 to 12 years of schooling, while 70 had 1 to 4 years of college. Fifty indicated that their husbands were in skilled occupations, 40 said their husbands were in a profession, and 11 had husbands who were students. The range of their own occupations is indicated in Table 1.

Table 1. Occupation of homemaker

Occupation	Number of Home-makers	Percent-age
Housewife	74	60.2%
Professional	22	17.9
Skilled	18	14.6
Student	4	3.3
Retired	4	3.3
No response	1	.8
Total	123	100.1%*

*Percentages are rounded off

About 1/3 of the homemakers had no children living at home, but the range of children per homemaker was from 0 to 7.

In answer to the question about income level, 15 indicated a less than $5,000 annual income, 24 were between $5,000 and $9,999, and 38 were in the $10,000 to $14,999 bracket. There were 20 in the $15,000 to $19,999 range and 13 in the $20,000 to $24,999 category. Five had annual incomes exceeding $25,000, and 8 did not answer the question.

The Appliances

Toasters and blenders were the most widely owned items on the list of 27 appliances (Table 2). Of the nonlisted, individually noted appliances, the grill or griddle had a place in 10 households (Table 3).

A major surprise came when the lists were converted to an appliances-owned-per-household basis (Table 4). Ownership trends were dramatically higher (an average of 10.7 appliances/household) than had been identified in previous studies. Both a 1960 (Pennsylvania) and a 1969 (Ohio) study had reported an average of 4.3 appliances per home. A 1975 (Alabama) study had indicated a 5.7 average/household.

Replies to questions about relative frequency of use gave the blenders a remarkable Jekyll/Hyde characterization (Table 5). The blender is the only appliance to appear among the top 5 in both the most and the least frequently used categories.

When Ms. Braegger correlated frequency of use with method of acquisition (gift or purchase), her results (Table 6) indicated that gift givers often misjudge in trying to match appliances and people. The "seldom or never used" description was applied to 233 gift appliances but only 76 self-purchased items.

Why the Differences?

Ms. Braegger tried to get at the why's of use differences in terms of storage space availability; appliance performance; design (safety, and ease of assembly, use and cleaning); and adequacy of instructions. For the 123 homemakers in this study, convenience of storage space did not significantly affect frequency of use. But performance, design, and quality of instructions were definitely factors.

Some of the comments about specific electric appliances were:

Can opener "problem to keep clean"
"doesn't open a can as easily as a manual one"

"takes too much space on the counter"
"for older people whose fingers are getting stiff, it is a godsend."

Knife
"can cut better with a regular knife"
"regular knife is faster"
"just don't take the time to get it out"

Frying pan
"too hard to get out of the cupboard"
"a bother to clean"

Blender
"I don't like washing it, and it doesn't work well"
"easier to use a knife"
"bulky and hard to store"
"too much bother to clean"

Apparently, whether a specific kitchen appliance turns out to be a burden or a boon depends on individualized attitudes and needs. So perhaps the next time a gift-giving occasion turns up, and you are looking at kitchen appliances, you may want to first consider whether such a gadget will accurately "fit" the lifestyle and needs of your intended recipients.

Table 2. Number of small electrical kitchen appliances owned

Appliance	Number Owned	% of Households Owning
Toaster	116	94.3%
Blender	115	93.5
Electric Frying Pan	110	89.4
Electric Hand Mixer	108	87.8
Electric Can Opener	96	78.0
Electric Corn Popper	85	69.1
Electric Slow Cooker	76	61.8
Electric Knife	64	52.0
Waffle Iron with Grill	58	47.2
Standard Large Mixer	55	44.7
Waffle Iron	55	44.7
Deep Fat Fryer	51	41.5
Electric Ice Cream Freezer	46	37.4
Toaster Oven	37	30.1
Electric Coffeemaker	32	26.0
Electric Warming Tray	28	22.8
Electric Wheat Grinder	25	20.3
Electric Fondue Pot	21	17.1
Electric Bun Warmer	19	15.4
Electric Egg Cooker	18	14.6
Electric Bread Mixer	17	13.8
Multi-appliance Center	15	12.2
Portable Broiler	14	11.4
Electric Hamburger Cooker	14	11.4
Electric Hot Dog Cooker	12	9.8
Electric Casserole	4	3.3
Electric Roaster	4	3.3

Table 3. Number of homemakers listing appliances not shown on questionnaire

Appliance	Number of Homemakers
Grill or griddle	10
Bag sealer	3
Food Dehydrator	2
Electric Juicer	1
Bacon Cooker	1
Yogurt Maker	1
Cooking Plate	1
Electric Salad Maker	1
Electric Ice Crusher	1
Electric Rotisserie	1
Electric Rice Cooker	1
Electric Bean Pot	1
Electric Grinder and Slicer	1

Table 4. Appliances owned per homemaker

Number of Appliances Owned	Number of Households	Percentage of Households
5	2	1.6%
6	8	6.5
7	13	10.5
8	12	9.8
9	13	10.6
10	15	12.2
11	10	8.1
12	11	8.9
13	11	8.9
14	12	9.8
15	4	3.3
16	5	4.1
17	4	3.3
19	2	1.6
No response	1	.8
Total	123	100.0%

Table 5. Appliances listed according to amount of use

Appliance	Times Listed as Frequently Used	Times Listed as Seldom or Never Used
Blender	44*	23**
Multi-appliance Center	2	1
Electric Can Opener	41*	15
Toaster	77*	6
Toaster Oven	14	9
Broiler	4	1
Electric Hand Mixer	54*	5
Standard Large Mixer	14	5
Electric Hot Dog Cooker	1	8
Electric Bun Warmer	0	12
Electric Coffeemaker	9	11
Electric Corn Popper	4	38**
Electric Fondue Pot	0	14
Electric Egg Cooker	0	5
Electric Bread Mixer	8	0
Electric Wheat Grinder	1	5
Electric Ice Cream Freezer	2	18
Electric Frying Pan	47*	19
Waffle Iron	4	15
Waffle Iron with Grill	9	17
Electric Slow Cooker	14	24**
Deep Fat Fryer	3	27**
Electric Casserole	0	2
Electric Roaster	0	2
Electric Knife	5	29**
Electric Hamburger Cooker	2	2
Electric Warming Tray	1	13
Appliances written in	6	8
No response	3	35

*Five appliances listed most often as frequently used.
**Five appliances listed most often as seldom or never used.

Table 6. Method of acquisition compared to amount of appliance use

	Purchased		Gift		No Response		Total
Amount of Use	No. of appliances	%	No. of appliances	%	No. of appliances	%	%
Frequently Used	138	37.4%	199	53.9%	32	8.7%	99.8%
Seldom or Never Used	76	20.6	233	63.1	60	16.3	100.0
Total	214		432		92		

Jane L. McCullough is Assistant Professor, Department of Home Economics and Consumer Education, USU.

A Quest for Compatibility: Plants and Intermountain Landscaping

Lois M. Cox

The "Why" of the Search

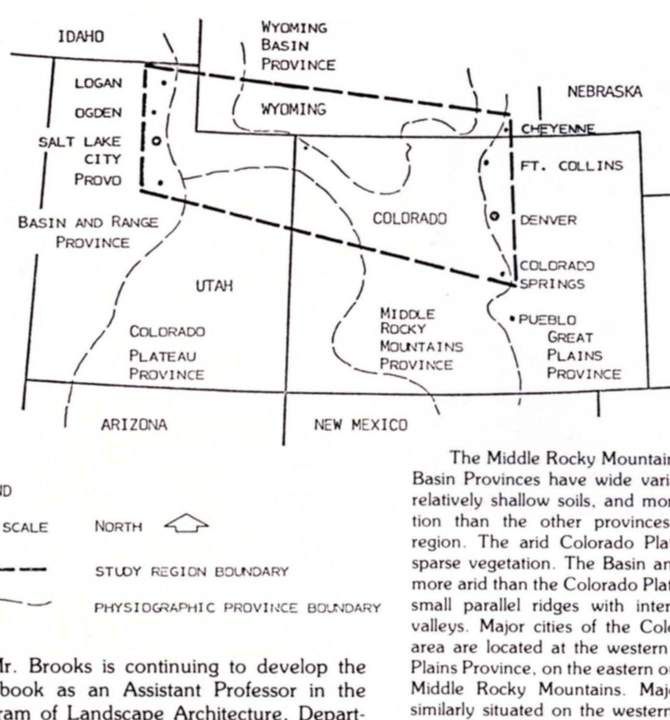
Sometimes a survey, done to see if research is warranted on a given topic, develops information that is valuable on its own. That's the way it went for Kenneth R. Brooks. Mr. Brooks started out to determine whether landscape architects and horticulturists in the Intermountain West needed their own special handbook of plant and environment compatability.

Enroute to an ultimately emphatic "yes" answer, Brooks first discovered that he'd have to strictly define his geographical boundaries (Figure 1). Next he realized that environmental variables in even his limited area of concentration were sufficiently rigorous to eliminate all but uniquely qualified ornamental plants. Only then could he start accumulating data about potential vegetative candidates for Intermountain landscapes.

His preliminary results, though far from complete, look as if they might have value for professionals and do-it-yourself homeowners in the region Brooks had chosen to study. That is the information we are previewing here.

The evaluation and analytical procedures Brooks applied and the form he proposes for the handbook are described in detail in *Plant Material Information Needs of Landscape Architects and Horticulturists in the Intermountain Region* (Master's Thesis, Utah State University, 1977).* In this article we briefly outline the variables that affect plant survival potentials in the Intermountain area and the criteria Brooks used to identify ornamentals with high survival probabilities. We also present the list of plants that earned his "most likely to succeed" accolade and a sample plant "information sheet" (Figure 2).

Figure 1. Brooks' Intermountain study region and its physiographic provinces.



LEGEND

NO SCALE NORTH

STUDY REGION BOUNDARY

PHYSIOGRAPHIC PROVINCE BOUNDARY

The Middle Rocky Mountain and the Wyoming Basin Provinces have wide variations in elevation, relatively shallow soils, and more annual precipitation than the other provinces in Brooks' study region. The arid Colorado Plateau supports only sparse vegetation. The Basin and Range Province, more arid than the Colorado Plateau, has numerous small parallel ridges with intervening broad, flat valleys. Major cities of the Colorado Front Range area are located at the western edge of the Great Plains Province, on the eastern outwash plains of the Middle Rocky Mountains. Major Utah cities are similarly situated on the western outwash plains of the Wasatch Range. [Source: Charles B. Hunt, *Physiography of the United States* (San Francisco: W. H. Freeman & Co., V, 1967).]

*Mr. Brooks is continuing to develop the handbook as an Assistant Professor in the Program of Landscape Architecture, Department of Horticulture, Washington State University, Pullman, Washington 99164.

Redbud

Selected shade trees, shrubs, herbaceous perennials, and annual flowers constitute a well developed garden.

Figure 2. Sample plant materials information sheet.

Cercis canadensis Eastern Redbud

TYPE:	Deciduous tree
FAMILY:	Leguminosae
OTHER NAMES:	Judas Tree

ENVIRONMENTAL AND CULTURAL ADAPTATION

ZONE:	4 INTRODUCED: 1641
ORIGIN:	Native to northeastern United States
ASSOCIATION:	An understory tree in eastern hardwood forests
SOIL & MOISTURE:	Prefers light, rich, moist soil
EXPOSURE:	Sun or partial shade; better if protected from western sun; does not tolerate windy exposures
TRANSPLANTING & MAINTENANCE:	Transplant only in spring while tree is young; tolerant to pruning

LANDSCAPE VALUE AND USE

FORM:	A small deciduous tree with broad rounded or irregular head; branches horizontal, spreading and angular; usually low branched
TEXTURE:	Medium
ULTIMATE SIZE:	Ht. 7.6 m (25 ft.) Spread 6.1 m (20 ft.) possibly larger in free standing areas
TWENTY YEAR SIZE:	Ht. 6.1 m (20 ft.) Spread 4.6 m (15 ft.)
RATE OF GROWTH:	Slow LIFE SPAN: Short to moderate
SPACING FOR MASSING:	3.8-4.6 m on center (12-15 ft)
AVAILABILITY:	Most nurseries, most common in small sizes
RELATIVE COST:	Moderate
VALUE, USE, & RESTRICTIONS:	Beautiful early blossoms; good foliage, open and picturesque; useful as a small specimen or as an understory tree to contrast with larger trees, especially large evergreen trees; best in protected areas, not always winter hardy

BOTANICAL DESCRIPTION

FOLIAGE:	Deciduous; alternate; simple, broadly cordate; 7.6-12.7 cm (3-5 in.) across, margin entire; tip acuminate to acute; base cordate; with prominent radiating veins; glabrous to pubescent beneath; petiole about 1/3 as long as blade; bronze-green in spring, blue-green to dull green in summer; purple-bronze to yellow-bronze in autumn
INFLORESCENCE:	Very showy; early spring before the leaves; rosy-pink; about 1.2 cm (½ in.) long; in racemes; perfect; typical pea-shaped flower
FRUIT:	Conspicuous; early fall; legume pod about 5.1-8.9 cm (2-3½ in.) long; light brown
BARK & TWIGS:	Bark is dark red-gray; twigs dark or almost black, glabrous, with zig-zag character
BUDS:	Small, glabrous, ovoid, pinkish; upper bud slightly stalked; lower ones sessile, often superposed
ROOTS:	Fibrous, but limited and poor; not forming leguminous root nodules

VARIETIES AND SUBSPECIES

Cercis canadensis alba — **White Eastern Redbud**
Flowers are white

Cercis canadensis 'Oklahoma' — **Oklahoma Eastern Redbud**
Flowers are wine-red

Cercis canadensis plena — **Eastern Redbud**
Flowers double, red

The Plant's Perspective

Life in the Intermountain Region, wherever you place the geographic boundaries, is anything but easy for the average plant. In fact, if you were an average plant, you'd probably rather live in parts of California or Oregon than in northern Utah or the Colorado Rockies. On the other hand, if you were a nonaverage plant that had been genetically programmed to accept a cold-dry environment, you could have a tough time surviving in mild, damp conditions. What that boils down to, is that whether a plant can fulfill its genetically set destiny depends mostly on where it finds itself growing.

And, to plants, the Intermountain Region presents a forbidding array of landforms (Figure 1) compounded by fluctuating temperatures, high wind velocities, intense sunlight, low humidities, low annual precipitation averages, and alkaline soils. Local realities, of course, can be far different, but the prevailing pattern is harsh. Such conditions are enough to make even some of our native plants long to emigrate in search of less stringent conditions. And it is a safe bet that many of our imported ornamentals wish they'd never been forced to leave home.

The daily high and low temperatures in the study region can be separated by as much as from -1° to 4°C (30° to 40°F). Precipitation tends to be higher at the higher elevations, but whether on the mountains or in the valleys it mostly comes in the winter rather than during the plant-growth months. For example, only about 152 mm (6 in) of the 406 to 508 mm (16 to 20 in) that Salt Lake City averages annually are received between April and September. Along with its minimal natural precipitation, the region confronts its vegetative inhabitants with a low relative humidity, which increases their need for moisture.

And then there are the winds, which are more than brisk in much of the region. As they climb in elevation to pass over the mountains, the winds decrease in velocity, temperature level, and moisture-holding capacity. Once over the peaks, they regain some of their velocity, temperature, and moisture-holding capacity. In both their up and down passages, however, the winds remove moisture from the tissues of any plants in their path.

The increased intensity of sunlight in the region's extensive areas of high elevation can mean additional problems for some plants. At a mile above sea level, the atmosphere is less effective at filtering solar radiation than it is at lower elevations. The result for nontolerant plants such as yews, myrtle, and English ivy can be sunburned (malfunctioning) foliage.

Many of the soils in the Brooks study area are characteristically shallow and decidely alkaline, with pH values of 8.0 or higher, except where their natural state has been altered by human manipulation. For plants, alkaline soils mean trouble in obtaining sufficient iron. Intermountain soils also tend to be low in residual organic matter, which reduces fertility and makes the soil structure relatively inhospitable to plant roots.

If the plants could be surveyed, they'd probably rank the Intermountain Region as being short on plus factors. The relative scar-

Combinations, using plants indigenous to your region with plants from other locations, create a casual environment in context with your surroundings.

Small trees and shrubs provide background for this annual flower garden viewed just after planting in May.

city of bacterial and fungal disease organisms is certainly one plus, but it is gained at the cost of aridity and wildly fluctuating temperatures. The same climatic factors help limit, but by no means eliminate, insect populations. All in all, nature confers few favors on plants in the Intermountain Region. Instead, they must be rugged enough to tolerate:

low annual precipitation,
wide daily temperature fluctuations,
low annual minimum temperatures,
low relative humidity,
drying winds high in velocity,
intense solar radiation, and
shallow soils that are low in organic matter (fertility), poor in structure, and high in pH.

The Human's Evaluation Process

Awareness of how nature challenges plants in the Intermountain Region allowed Brooks to ignore a lot of ornamentals that thrive elsewhere in the United States. He knew, however, that a simple listing of the remainder would do little to solve the headaches of either professional or amateur landscapers. So his next step was to ask 19 experts with extensive Intermountain experience to review his preliminary list of:

208 species or subspecies of broadleaf trees
53 species or subspecies of coniferous trees
239 species or subspecies of broadleaf shrubs
71 species or subspecies of coniferou shrubs
24 species or subspecies of vines
22 species or subspecies of ground covers
10 species or subspecies of ornamental grasses
7 species of miscellaneous materials.

Of the 19 horticulturists, practicing landscape architects, foresters, and nurserymen that were contacted, 15 responded. Each specialist had been asked to evaluate Brooks' list of plants on the basis of how they perceived each species':

1) tolerance for Intermountain climatic and microclimatic conditions,
2) availability in the region (whether imported, propagated, or collected), and
3) potentials for aesthetic or utilitarian usefulness in an Intermountain landscape.

All in all, nature confers few favors on plants in the Intermountain Region

Based on the answers he received, Brooks evolved two lists of plants that would be treated in detail in the handbook. In his first (primary) list (Table 1), he put the plants that had received an overall fitness rating of at least 75 percent on all counts from all respondents. The second included the plants that had earned overall ratings of between 50 and 74 percent. These had been cited by the experts as having their usefulness restricted by factors such as limited hardiness or low availability.

This article presents only Brooks' list of primary plants, the ones deemed least likely to respond to loving care by dying in their first or second season. The plants with an asterisk (*) by the scientific name can be observed at the Utah Agricultural Experiment Station's Farmington Display Gardens. Those with a plus (+) are *especially* well suited to conditions along the Wasatch Front.

The Practical Outcome

To use the list as a reference, you must keep the scientific names in mind since the "common" names can vary with the nursery. For example, a River Birch may be either a *Betula occidentalis*, a *Betula fontinalis*, or a *Betula papyrifera*, depending on whom you ask. Each of these species will react differently in a landscape, and they differ in their resistance to birch-favoring diseases.

But not even the scientific names are foolproof. The crimson king Norway Maple, for example, is known as both *Acer platanoides* "Crimson King" and as *Acer platanoides schwedleri nigra*. A similar problem has come up because botanists now believe the genera *Mahonia* (Grape Holly) would be more correctly called *Berberis* (Barberry). Nurseries, however, continue to sell the plants as *Mahonia*.

Also, to achieve long-term, visually pleasing combinations of ornamental plants, you will have to be alert to seasonally-induced changes in each plant's color, texture, overall form, and maintenance needs. Then, too, even plants that have proved their adapability to the Intermountain Region can give you less than their genetically possible "best" performance. All you have to do is neglect to precisely match

each one to its preferred microclimatic conditions. For instance, shading by a larger plant, or a wall, or a boulder, can create an environment within an environment—as can an artificial supply of moisture, or a fence, or building-created protection from the wind.*

In other words, the list (and eventually the handbook), can up the odds on your chances of being satisfied with your landscaping efforts. It is not, however, imbued with magic. Nothing, absolutely nothing, can guarantee that you'll avoid the occasional misfit plant or the ingrate that simply refuses to survive. Nature will rarely relinquish her right to evade total predictability.

*For further information on Utah plants see "Do It Yourself Landscaping," by William A. Varga in *Utah Science* 38, No. 4 (December 1977):113-122.

Table 1. Primary list of plant materials for the Intermountain region.

BROADLEAF TREES

+*Acer ginnala*	Amur Maple
+*Acer glabrum*	Rocky Mountain Maple
Acer negundo	Boxelder
+*Acer platanoides*	Norway Maple
•+*Acer platanoides columnare*	Columnar Norway Maple
Acer platanoides 'Emerald Queen'	Emerald Queen Norway Maple
Acer platanoides schwedleri	Schwedler Norway Maple
•*Acer saccharinum*	Soft Maple
Aesculus glabra	Ohio Buckeye
+*Aesculus hippocastanum*	Horsechestnut
Ailanthus altissima	Tree of Heaven
Alnus tenuifolia	Thinleaf Alder
+*Betula fontinalis*	Native River Birch
+*Betula papyrifera*	Paper Birch
•*Betula pendula*	European White Birch
•*Betula pendula gracilis*	Weeping European White Birch
Catalpa speciosa	Western Catalpa
Celtis occidentalis	Common Hackberry
•+*Cercis canadensis*	Eastern Redbud
Crataegus crus-galli	Cockspur Thorn
+*Crataegus lavallei*	Carrier Hawthorn
Crataegus oxyacantha	English Hawthorn
Crataegus oxyacantha paulii	Paul's Scarlet Hawthorn
•+*Crataegus phaenopyrum*	Washington Thorn
Elaeagnus angustifolia	Russian Olive
Fraxinus americana	White Ash
Fraxinus pennsylvanica lanceolata	Green Ash
+*Fraxinus pennsylvanica lanceolata* 'Marshall Seedless'	Marshall Seedless Green Ash
Fraxinus pennsylvanica lanceolata 'Summit'	Summit Green Ash
Gleditsia triacanthos	Honeylocust
Gleditsia triacanthos inermis	Thornless Honeylocust
Gleditsia triacanthos inermis 'Moraine'	Moraine Honeylocust
+*Gleditsia triacanthos inermis* 'Shademaster'	Shademaster Honeylocust
Gleditsia triacanthos inermis 'Skyline'	Skyline Honeylocust
Gleditsia triacanthos inermis 'Sunburst'	Sunburst Honeylocust
+*Gymnocladus dioicus*	Kentucky Coffee Tree
Juglans nigra	Black Walnut
•+*Koelreuteria paniculata*	Goldenrain Tree
Laburnum vossi	Golden Chain Tree
Liriodendron tulipifera	Tulip Tree
•*Malus* 'Almey'	Almey Crabapple
•+*Malus* 'Dolgo'	Dolgo Crabapple
Malus 'Dorothea'	Dorothea Crabapple
•+*Malus* 'Hopa'	Hopa Crabapple
+*Malus ioensis plena*	Bechtel Crabapple
Malus 'Pink Perfection'	Pink Perfection Crabapple
Malus purpurea 'Eleyi'	Eley Crabapple
Malus 'Radiant'	Radiant Crabapple
+*Malus* 'Red Jade'	Red Jade Crabapple
•+*Malus* 'Royalty'	Royalty Crabapple

Vines can provide screening, shade, and an additional food source as does this grape vine.

Many useful trees and shrubs are displayed at sizes approaching maturity at USU's Farmington Gardens.

Malus sargentii	Sargent Crabapple
Malus 'Snow Cloud'	Snow Cloud Crabapple
•+*Malus* 'Strathmore'	Strathmore Crabapple
Platanus occidentalis	American Plane Tree
Populus alba	White Poplar
Populus alba pyramidalis	Bolleana Poplar
Populus angustifolia	Narrowleaf Cottonwood
Populus nigra italica	Lombardy Poplar
Populus sargentii	Plains Cottonwood
•*Populus tremuloides*	Quaking Aspen
Prunus cerasifera 'Newport'	Newport Flowering Plum
•+*Prunus padus commutata*	May Day Tree
Prunus virginiana	Chokecherry
Prunus virginiana demissa	Western Chokecherry
Quercus borealis	Northern Red Oak
+*Quercus gambellii*	Gambel Oak
•+*Quercus macrocarpa*	Bur Oak
Quercus robur	English Oak
Sorbus aucuparia	European Mountain Ash
•+*Syringa amurensis japonica*	Japanese Tree Lilac
Tilia americana	American Linden
+*Tilia cordata*	Littleleaf Linden
Tilia cordata 'Greenspire'	Greenspire Littleleaf Linden

CONIFEROUS TREES

Abies concolor	White Fir
•*Juniperus scopulorum*	Rocky Mountain Juniper
Abies concolor	White Fir
Juniperus scopulorum	Rocky Mountain Juniper
•+*Juniperus scopulorum* 'Blue Haven'	Blue Haven Juniper
•+*Juniperus scopulorum* 'Grey Gleam'	Grey Gleam Juniper
+*Juniperus scopulorum* 'Pathfinder'	Pathfinder Juniper
•*Juniperus virginiana*	Eastern Red Cedar
•*Juniperius virginiana camaertii*	Canaert Juniper
•+*Juniperus virginiana cupressifolia*	Hillspire Juniper
+*Picea abies*	Norway Spruce
Picea engelmannii	Englemann Spruce
•*Picea pungens*	Colorado Spruce
•*Picea pungens glauca*	Colorado Blue Spruce
•+*Pinus aristata*	Bristle Cone Pine
Pinus densiflora umbraculifera	Japanese Tabletop Pine
+*Pinus edulis*	Pinyon Pine
+*Pinus flexilis*	Limber Pine
+*Pinus mugo*	Swiss Mountain Pine
+*Pinus nigra*	Austrian Pine
•*Pinus ponderosa*	Western Yellow Pine
Pinus sylvestris	Scotch Pine
+*Pseudotsuga menziesii*	Douglas Fir
•*Thuja occidentalis*	American Arborvitae

BROADLEAF SHRUBS

•*Artemisia tridentata*	Big Sagebrush
+*Berberis mentorensis*	Mentor Barberry
•*Berberis thunbergii*	Japanese Barberry
•*Berberis thunbergii atropurpurea*	Redleaf Barberry

*Berberis thunbergii 'Crimson Pygmy'	Crimson Pygmy Japanese Barberry
*Buddleia davidii	Common Butterflybush
*+Caragana arborescens	Siberian Pea Shrub
Chaenomeles speciosa	Flowering Japanese Quince
*+Chaenomeles speciosa 'Texas Scarlet'	Texas Scarlet Flowering Quince
*+Cornus stolonifera	Red Osier Dogwood
Cornus stolonifera coloradensis	Colorado Red Osier Dogwood
+Cornus stolonifera flaviramea	Yellowtwig Dogwood
*+Cotoneaster acutifolia	Peking Cotoneaster
*+Cotoneaster apiculata	Cranberry Cotoneaster
*+Cotoneaster divaricata	Spreading Cotoneaster
*Euonymus alatus	Winged Euonymus
*+Euonymus alatus compacta	Dwarf Winged Euonymus
Euonymus atropurpureus	Burning Bush
*Euonymus europaeus	European Eunoymus
*+Euonymus fortunei	Wintercreeper
+Euonymus fortunei coloratus	Purple Wintercreeper
Euonymus fortunei radicans	Wintercreeper
Euonymus fortunei vegetus	Bigleaf Wintercreeper
*+Forsythia 'Arnold Dwarf'	Arnold Dwarf Forsythia
Forsythia intermedia	Goldenbells
*+Forsythia intermedia 'Linwood Gold'	Linwood Gold Goldenbells
Forsythia suspensa	Weeping Forsythia
*+Kolkwitzia amabilis	Beauty Bush
Ligustrum vicaryi	Golden Vicary
*+Ligustrum vulgare	European Privet
+Ligustrum vulgare 'Lodense'	Lodense European Privet
+Lonicera tatarica	Tatarian Honeysuckle
*+Lonicera tatarica zabeli	Zabel Honeysuckle
*+Mahonia aquifolium	Oregon Grape Holly
*+Mahonia aquifolium compacta	Dwarf Oregon Grape Holly
+Philadelphus lemoinei	Lemoine Mockorange
+Philadelphus virginalis	Virginal Mockorange
*+Potentilla fruticosa	Shrubby Cinquefoil
*Potentilla fruticosa 'Klondike'	Klondike Cinquefoil
Prunus cistina	Purpleleaf Plum
+Prunus glanulosa	Dwarf Flowering Almond
*Prunus laurocerasus	English Laurel
Prunus tomentosa	Nanking Cherry
Prunus triloba	Flowering Plum
*+Pyracantha coccinea 'Wyattii'	Wyattii Firethorn
*Pyracantha pauciflora	Firethorn
+Rhamnus catnartica	Common Buckthorn
Rhamnus frangula colum-naris	Tallhedge Buckthorn
*+Rhus glabra	Smooth Sumac
Rhus glabra cismontana	Rocky Mountain Smooth Sumac
Rhus glabra laciniata	Laceleaf Smooth Sumac
+Rhus trilobata	Skunk Bush Sumac
*+Rhus typhina	Staghorn Sumac
+Rhus typhina laciniata	Laceleaf Staghorn Sumac
*+Ribes alpinum	Alpine Currant
+Rosa hugonis	Father Hugo's Rose

Pines are useful in large plantings for screening and winter color. (This is a Ponderosa.)

Combine size, texture, and color in your shrub plan. (*Forsythia* is in the foreground.)

Salix discolor	Pussy Willow
+*Sambucus canadensis*	American Elderberry
•*Sambucus canadensis aurea*	Golden Elder
•+*Shepherdia argentea*	Silver Buffaloberry
•+*Spiraea bumalda*	Bumalda Spirea
•+*Spiraea bumalda froebelii*	Froebel Pink Spirea
•+*Spiraea vanhouttei*	Vanhoutte Spirea
+*Symphoricarpos albus*	Common Snowberry
Symphoricarpos orbiculatus	Indian Currant
+*Symphoricarpos orbiculatus chenaulti*	Chenault Coralberry
Syringa chinensis	Chinese Lilac
•+*Syringa persica*	Persian Lilac
•+*Syringa vulgaris*	Common Lilac
Syringa vulgaris 'Charles Jolley'	Charles Jolley Common Lilac
•+*Viburnum burkwoodii*	Burkwood Viburnum
Viburnum dentatum	Arrowwood
•*Viburnum lantana*	Wayfaring Tree
•*Viburnum opulus*	European Cranberrybush
Viburnum opulus compacta	Dwarf European Cranberrybush
+*Viburnum opulus nanum*	Dwarf European Cranberrybush
•*Viburnum opulus sterile*	Common Snowball
+*Viburnum trilobum*	American Highbush Cranberry

CONIFEROUS SHRUBS

•+*Juniperus chinensis armstrongi*	Armstrong Juniper
+*Juniperus chinensis* 'Blaauwi'	Blaauwi Juniper
•+*Juniperus chinensis hetzii*	Hetz Juniper
+*Juniperus chinensis* 'Mint Julep'	Mint Julep Juniper
•+*Juniperus chinensis pftizeriana*	Pftizer Juniper
+*Juniperus chinensis pftizeriana aurea*	Golden Pfitzer Juniper
+*Juniperus chinensis pftizeriana compacta*	Compact Pfitzer Juniper
+*Juniperus chinensis pftizeriana glauca*	Blue Pfitzer Juniper
•+*Juniperus chinensis procumbens* 'Green Mound'	Green Mound Juniper
•+*Juniperus chinensis* 'Sea Green'	Sea Green Juniper
•+*Juniperus communis*	Common Juniper
•+*Juniperus sabina* 'Broadmoor'	Broadmoor Juniper
•+*Juniperus sabina* 'Buffalo'	Buffalo Juniper
•+*Juniperus sabina* 'Scandia'	Scandia Juniper
+*Juniperus sabina tamariscifolia*	Tam Juniper
•+*Picea abies nidiformis*	Nest Spruce
•+*Picea glauca conica*	Alberta Spruce
•+*Pinus mugo mughus*	Dwarf Mugo Pine
•+*Taxus cuspidata*	Japanese Yew
•+*Taxus media* 'Hicksii'	Hicks Yew

VINES

•+*Campsis radicans*	Trumpet Vine
•+*Clematis jackmanii*	Jackman Clematis
•*Hedera helix*	English Ivy
•+*Hedera helix baltica*	Baltic Ivy
•+*Lonicera japonica* 'Halliana'	Hall's Honeysuckle
+*Parthenocissus quinquefolia*	Virginia Creeper
•+*Parthenocissus tricuspidata*	Boston Ivy
+*Polygonum aubertii*	Silver-lace Vine
•+*Vinca minor*	Periwinkle

GROUND COVERS

•*Ajuga reptans*	Carpet Bugle
•+*Arctostaphyllos uva-ursi*	Bearberry
•+*Cerastium tomentosum*	Snow in Summer
•*Juniperus horizontalis*	Creeping Juniper
•+*Juniperus horizontalis* 'Bar Harbor'	Bar Harbor Juniper
•*Juniperus horizontalis plumosa*	Andorra Juniper
•+*Juniperus horizontalis plumosa compacta*	Compact Andorra Juniper
•*Juniperus horizontalis* 'Wiltoni'	Wilton Juniper
•*Juniperus procumbens nana*	Dwarf Japgarden Juniper
•+*Mahonia repens*	Creeping Mahonia
•+*Sedum acre*	Goldmoss Sedum
•+*Sedum spurium*	Stonecrop

ORNAMENTAL GRASSES

•+*Festuca ovina glauca*	Blue Fescue
Nandina domestica	Heavenly Bamboo

MISCELLANEOUS MATERIALS

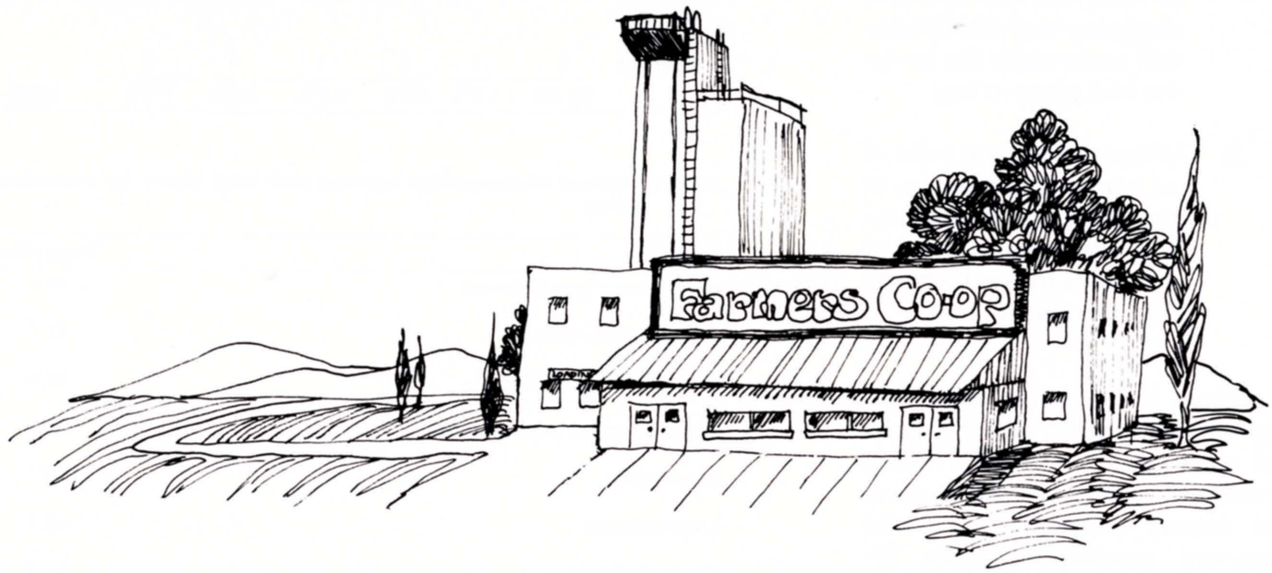
•+*Yucca filamentosa*	Adam's Needle
•+*Yucca glauca*	Great Plains Yucca

Lois M. Cox is Science Writer, Agricultural Experiment Station Publications, USU.

Photos by William A. Varga and Carol Grundmann

The Participation Problems of Co-ops

John G. Wark and Therel R. Black



In theory, farmers' cooperatives' open membership, democratic control, and return of dividends should insure maximum participation by their members. Instead, members often choose to make their purchases elsewhere. The research described here was conducted to try to find out why theory and practice diverge. Specifically, we wanted to define various degrees of participation and identify factors associated with each.

Historically, social and economic conditions have influenced the members' level of participation. For example, as the organizations increased in size, professional decision-making was substituted for member participation in the decision process. The individual's relationship to the cooperative thus shifted toward an impersonal level. This trend aggravated the problem of member participation.

Data Collection

A pretested questionnaire was sent to 323 randomly selected individuals among the 2,266 members of the cooperative. A total of 159 usable replies were obtained.

Selected Findings

Extent of participation

Co-op participation was measured by dividing it into 2 related variables, that is, degree of patronage and number of annual meetings attended during the previous 5 years. Patronage was measured by the question, "Of the products that you could buy from the co-op, what percentage did you buy?" Attendance was measured by the question, "In the last 5 years how many of the co-op's annual meetings have you attended?" Patronage was used as a measure of the members' economic participation, while attendance served as a measure of the members' social participation (Table 1).

The whys of patronage

In general, the responding members indicated that they patronized the co-op because of high quality products and good service (Table 2). They attended the annual meeting because of social factors such as whether or not their friends and neighbors bought at the co-op as well as because of the quality of the co-op's service.

Relevance of price, costs of transportation to and from the co-op, and return of dividends

Another item on the questionnaire was: "Which one of the following best describes your decision to buy at the co-op?

1) When the price of an item is lower than elsewhere.

2) When the present price of an item and differences in shopping and transportation costs make the co-op the best place to buy.

3) When the present price of an item and differences in shopping and transportation costs plus return of dividends make the co-op the best place to buy."

When the answers were correlated with the members' degree of patronage, we found a strong relationship between the number of factors considered and the amount purchased (Table 3). Members who considered both price and transportation costs, consistently purchased more than those considering only price. This relationship also held for members who considered all three factors—price, transportation costs, and return of dividends—before purchasing. In other words, the more factors considered, the more likely it was that purchases would be made at the co-op.

Conclusions

In summary, the responding co-op members tended to participate economically because of the service, quality of goods, and convenience. They participated socially (by attending the annual meetings) because their friends and neighbors patronized the co-op and because of the quality of the co-op's service. An especially useful finding of this study was that the more economic factors (price, transportation, return of dividends) members considered before purchasing, the more they purchased from the co-op. Apparently participation could be increased by making members more aware of *all* the relevant economic factors.

Table 1. Participation as measured by patronage and attendance

Participation	Responses						Totals %	Totals N
Degree of Patronage:	0%-25%		25%-50%	50%-75%		75% +		
	43.4%		22.9%	19.1%		14.6%	100%	(157)
Number of Annual Meetings Attended:	0	1	2	3	4	5		
	72.8%	5.2%	7.8%	4.5%	2.6%	7.1%	100%	(154)

Table 2. Percent of respondents agreeing with each reason for patronizing the co-op

Reason	% Agreeing
Good service from the co-op	91.6
Good quality products	91.6
Convenience of location	82.1
Co-op principles of cooperation	76.7
Lower prices	73.5
Large selection	62.3
Co-op dividends	51.3
My friends and neighbors buy there	37.6

Table 3. The relationship of three economic considerations to the degree that members used the co-op

Factor	Percentage of purchases made at the co-op: Purchased less than 25%	Purchased more than 25%
Price	42.6%	12.5%
Price + Transportation	38.9%	40.0%
Price + Transportation + Dividend	18.5%	47.5%
Total	100.0%	100.0%
N	(54)	(80)

$X^2 = 19.424$ with 2 df $p = .0001$
$G = 0.585$

The X^2 value indicates that the relationship is unlikely to have happened by chance.
The G value indicates that the relationship is quite strong.

John C. Wark is a graduate student in the Department of Sociology, Social Work, and Anthropology, USU.

Therel R. Black is Professor, Department of Sociology, Social Work, and Anthropology, USU.

Employment and Migration

Carole Seyfrit and Mike Toney

Photo by Kent Fuellenbach

Until very recently rural areas throughout the United States have been plagued by population declines and their possibly associated problems. The large-scale out-migration of rural youth has been of particular concern.

Researchers have pointed out that the departing youths tend to be high school graduates in whom the communities have a considerable investment, and who would likely contribute to the advancement of their communities if they stayed.[1] This migration is usually viewed as being caused by a depressed economy and as resulting in further economic depression by making it harder to attract industry to the area.[2]

The primary aim of the research described here was to determine if students in Utah's rural counties that have had great increases in employment in mining types of energy development (mining) are more likely to plan to remain than are students in counties in which mining employment opportunities have not increased significantly. Mining is an especially important type of energy development because it usually creates a larger number of jobs than other types of energy development.[3]

Procedures

Approximately 900 high school seniors in rural counties throughout Utah were surveyed shortly before their graduation in 1975. We first considered answers to a question about where the students planned to live most of rest of their lives. While plans or intentions may not correspond perfectly with later actions, previous research has demonstrated that an intent to move is a very good predictor of future movement.[4] Responses to the question about future movement intentions also provided a good indicator of the overall attitude or perception of the youths toward their community.

Additional information from the survey was examined to determine if students planning to attend college were more likely to intend to leave permanently than were non-college-bound graduates. We also tried to determine if intentions to engage in different types of occupations equated with differences in movement plans.

Using existing data, we first classified counties as to high, medium, and low levels of employment in mining (Table 1). Because the counties with high levels of changes in mining employment increased in population size at a much greater rate than the other counties, we believe it probable that mining influences movement decisions. Such data, however, do not show whether the growth involves retention of youths.

Findings

None of Utah's 14 rural counties have lost population since 1970 although 13 of them lost population between 1960 and 1970 (Table 1). Some experts feel that the general recent regrowth of rural counties in the US might be partly due to a halting of large scale out-migration of youth combined with a small scale movement of urban people to rural areas.[5] If youth are continuing to leave rural areas in large numbers, then the number of people moving into the communities must be sufficient to more than offset this loss.

According to our research, over two-thirds of the 1975 high school graduates of rural Utah, 68.8 percent, intend to live most of the rest of their lives out of the rural communities where they were living at the time of graduating from high school (Table 2). Further, our respondents were as likely to intend to leave communities that had high levels of mining development as those with lower levels. Actually, counties with medium levels of energy development in mining had the smallest percentage of students intending to leave (62.8 percent). Those with high and low levels

Table 1. Changes in mining employment and population growth for rural Utah counties and percent of youth intending to out-migrate

Level of Energy Development for Counties	Percent Population* Change 1970-75	Percent Employed** in Mining 1974	Percentage Point*** Change in Mining Employment 1970-1974	Percent of Youth Intending to Leave
High	34.7	21.6	6.3	70.5
Duchesne		19.5	8.3	
Emery		28.5	6.9	
San Juan		20.2	5.3	
Medium	15.3	4.1	1.6	62.8
Summit		4.7	3.3	
Beaver		7.4	2.6	
Wayne		1.7	1.7	
Daggett		1.9	1.1	
Garfield		1.7	0.9	
Kane		1.7	0.9	
Low	13.6	1.4	-0.8	70.7
Morgan		0.6	0.6	
San Pete		0.4	0.4	
Millard		2.6	-0.8	
Piute		1.3	-3.4	
Rich		6.5	-9.0	

Sources: *Bureau of Economic and Business Research, *Utah Economic and Business Review* 36(11) (University of Utah, November, 1976).

**Bureau of Economic and Business Research, *Utah Economic Potential Files*, Industrial Development Information System (University of Utah, 1972).

***Bureau of Economic Research, *County and Community Economic Facts*, Utah Industrial Development Information Service (University of Utah Center of Economic and Community Development, 1975).

had 70 percent intending to leave. Thus, this type of energy development does not appear to be holding youth in rural communities.

Since the jobs provided by mining seem more likely to hold non-college- than college-bound high school graduates, the data were examined to determine if these two groups differ (Table 2). Of our respondents not figuring on college and who were living in a highly mining-impacted community, 71.5 percent intended to leave for most of the rest of their lives while 70 percent of the college-bound intended to do so. This can be compared with the 72.7 percent of non-college-bound students in counties with low levels of employment in mining who said they intended to leave.

Our survey results also revealed that various occupational aspirations did not modify intents to leave areas of either high or low levels of mining employment. For instance, of graduates aspiring to professional positions, 72.0 percent intended to leave counties with high levels of employment in mining, while just slightly more (76.8) intended to out-migrate from counties with the lowest levels of such development. The category of aspirations which includes those most directly related to mining types of energy jobs had slightly more students likely to be intending to leave high- than low-impacted counties, 67.7 and 63.4 percent, respectively. In general, our results do not indicate that high levels of employment in mining will hold youth in rural communities.

Conclusions

Our key finding was that the percentage of recent high school graduates intending to out-migrate from rural counties was basically the same regardless of the county's level of employment

Table 2. Long-term migration intentions relative to level of employment in mining, by educational aspirations and occupational goals

Migration Intentions	Employment in Mining: College-Bound High	College-Bound Medium	College-Bound Low	Non-college-Bound High	Non-college-Bound Medium	Non-college-Bound Low	All Rural Counties
	%	%	%	%	%	%	%
Migrant	70.0	56.0	67.0	71.5	67.3	72.7	68.5
Nonmigrant	30.0	44.0	33.0	28.5	32.7	27.3	31.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(n)	(123)	(113)	(176)	(100)	(75)	(100)	(688)

Migration Intentions	Professional			Sales, Managerial, Clerical			Operatives, Farmers, Laborers, Farmworkers			Service Workers, Housewives		
Energy Impact	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low
	%	%	%	%	%	%	%	%	%	%	%	%
Migrant	72.0	75.0	76.8	75.7	51.9	75.0	67.7	52.9	63.4	59.1	57.9	66.7
Nonmigrant	28.0	25.0	23.2	24.3	48.1	25.0	32.3	47.1	36.6	40.9	42.1	33.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(n)	(93)	(72)	(95)	(37)	(27)	(52)	(31)	(34)	(41)	(22)	(19)	(30)

in mining. Furthermore, this result held for college- and noncollege-bound youth as well as for those aspiring to different types of occupational careers. Around two-thirds of our respondents (in each county) intended to leave their home areas and to stay away most of the rest of their lives. (When interpreting these results it should be kept in mind that the actual movement of the youths might differ from their intentions, although past research indicates that most will follow through with stated intentions.)

Our data were collected a short time before high school graduation, when the youths are likely to be seriously reflecting on their future. Therefore, the announced migration intentions may provide a valid indicator of how the graduates evaluated long-term opportunities in their communities.

Since out-migration of youth contributed substantially to past population declines of rural areas, the resurgence of growth in these areas might have signaled the halting of their large-scale out-migration. Our research does not appear to substantiate this. Rather, the new growth seems likely to be due to large numbers of newcomers and perhaps to the return of previous out-migrants.

Our results suggest that the creation of employment opportunities, assumed to accompany mining development, may not be sufficient to slow the out-migration of rural youth. This may mean that other types of employment opportunities would not slow the out-migration of youth from rural areas either. The wider range of economic opportunities and the social and cultural offerings of large urban places may be too attractive for mere single-industry economic changes in rural areas to halt long-standing out-migration patterns of rural youth. It must be emphasized, however, that our results are suggestive rather than definitive since they are based on intentions. But a lack of recent information on the *actual* movement of rural youth enhances the worth of at least knowing intentions.

Creation of employment opportunities may not be sufficient to slow the out-migration of rural youth

Some individuals believe that young adults have finally halted their out-movement from rural areas because these areas are growing. These people then conclude that the communities involved must be attractive to this age group. Nevertheless, over 1,100 adult residents of 8 rural Utah communities, recently cited facilities for youths more often than any other aspect of the community as needing improvement.[6] These adults apparently still perceived their communities as being unattractive to young people, and their responses may help to explain why so many youths still plan to leave even communities that have had great increases in employment opportunities.

A follow-up study is now underway to determine the extent to which our sampled high school youths are following through on their movement intentions and other plans. We are also examining the attitudes of these youths toward rural communities and larger cities, and attempting to identify factors that determine the volume and direction of movement between them. Research into the characteristics of newcomers to rural areas is also underway. Results from that work should help us understand the population changes that are occurring and aid rural community leaders in planning for schools, housing, and other services population growth necessitates.

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[3]Dennis Norman, Fernando Henriques, and Clifford Slaughter, *Coal is Our Life*, 2nd ed. (New York: Tavistock Publication, 1969), p. 13.

[4]Alden Speare, Jr., Sidney Goldstein, and William H. Frey, *Residential Mobility, Migration and Metropolitan Change* (Cambridge, Mass.: Ballinger Publishing Company, 1974), p. 257.

[5]Beale, Calvin L. "Rural Development: Population and Settlement Prospects," *Journal of Soil and Water Conservation* 29 (1):23-27, 1975.

[6]Reed Geertsen, Michael Toney and Yun Kim, "Local Perceptions of Community Life in Rural Utah," *Utah Science* 38, No. 2 (June 1977):47

Carole Seyfrit is a graduate student in the Department of Sociology, Social Work, and Anthropology, USU.

Michael B. Toney is Assistant Professor, Department of Sociology, Social Work, and Anthropology, USU.

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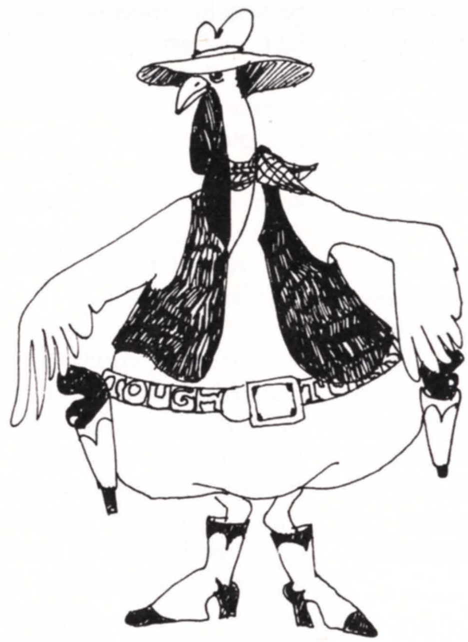
Projects in Progress

Lois M. Cox

In this regular feature of *Utah Science* we briefly describe some of the research in progress across the USU campus. Each installment is a scant sampling of the remarkably diverse research scene.

Self Preservation—even foods try for it



Look up formaldehyde in a dictionary, and you find that the chemical can be used as a disinfectant or as a preservative. It is also described as having a pungent odor—a fact to which any high school biology or university zoology student can bear witness. Certainly formaldehyde is not something you'd choose to include in your daily menu.

But, want it or not, most of us are probably eating at least minute amounts of formaldehyde almost every day. How much we take in over a month or a year depends on the kinds of foods we favor. What the chemical does in the human body is unknown. Intuitively, though, the prospects seem uninviting.

How can this be happening, you ask? Has *everyone* in the FDA been derelict? What are all those USDA food inspectors doing, for heaven's sake?

It is happening because until quite recently, no one had any reason to suspect that it might be. Then, about a year ago, Von T. Mendenhall (Assistant Professor of Nutrition and Food Science) and two graduate students (Stanley J. Andrews and Carolyn G. Ponce) decided to figure out why deboned, frozen turkey meat changed in flavor if it was stored frozen for more than approximately 60 days.

Their attention automatically went first toward the fat content of the meat since it is a chemical truism that unsaturated fats plus oxygen can equal flavor changes. Gradually they realized that, for deboned turkey, storage equals a progressive formation of formaldehyde and nonnutritive chemical compounds.

Later research involving other foods indicated that the turkey was not unique. Storage of any items containing unsaturated fats routinely meant that various aldehydes (including formaldehyde) *and* hydrocarbons (chemicals that have been implicated in some types of cancers) would be generated over time. Those data, combined with current trends in United States dietary habits (more unsaturated fats, more foods that have been stored for long periods) argued for continuing their investigations. Which they did.

As Dr. Mendenhall describes some of their subsequent work, "In our comparisons of cured versus uncured meats, we found that nitrites inhibit the formation of both aldehydes and hydrocarbons. Apparently, nitrites are not the unmitigated 'bad actors' that some people consider them to be. Right now, we're concentrating on analyzing powdered milk and frozen foods that we purchase off supermarket shelves."

Based on their preliminary results, all meats, TV dinners, and such high-fat foods as piecrust are the most likely to contain measurable amounts of formaldehyde (and other aldehydes) along with hydrocarbons. In addition to their ongoing chemical analyses, the researchers are trying to locate relevant analytical results produced elsewhere, collect original consumption information (how much of the chemicals are you and I eating?), and correlate storage life/time held/chemicals produced data for various foods.

Eventually, according to Dr. Mendenhall, they hope to complete some valid feeding trials with nonhuman animals. Only with such trials can they begin to define how the chemicals are processed by the body. He cautions, however, that the catch will be "the difficulty of finding a digestive system that duplicates ours."

Meanwhile, it looks as if assuring ourselves of a truly healthful diet is going to be an increasingly complicated chore.

Helping Nature Recuperate

Diversity within a species or a natural environment can enhance its survival potentials. For a scientist, however, diversity (whether in a species, a natural environment, or a man-created system) generally means vexation. In fact, when confronted by extreme diversity, the scientist tends to react with the reflex to classify the pieces into as few categories as possible. Categorization somehow implies manageability. And so it is with the puzzle of how to rehabilitate mining spoils and/or tailings.

First of all, spoils (unprocessed, discarded materials) differ from tailings (nonusable byproducts of the mining process). Second, drastic variations can occur within each category depending on geologic history of the area, kind of mining operation, age of the wastes, site exposure, and climate. Thus, every site and its wastes have their own assortment of hydrologic properties and fertility ratings (existing and/or attainable).

All this diversity guarantees that no single, sure-fire formula can be devised for rehabilitating land that has been disturbed by mining. On the other hand, it is patently impractical to do individualized research on each and every mining site.

One reaction to such a conglomerate of variables is to seek elsewhere for a research topic. Another alternative, however, is to choose a definable section and try to make sense of it. A research group headed by G. F. Gifford (Associate Professor of Rangeland Hydrology) has been applying that alternative philosophy to mining site problems in Utah. Their goal has been to evolve descriptive categories for spoils and tailings that would accurately indicate their hydrologically oriented rehabilitation potentials.

After investigating 60 active and abandoned sites, they have tentatively concluded that the waste materials *can* be hydrologically evaluated as to "susceptibility to supporting vegetation" based on infiltration rates and erodability. These two

characteristics, in turn, depend primarily on the texture and slope of the wastes, soil porosity, and the prevailing climate.

"When all these factors are brought into focus," says Dr. Gifford, "we have 6 classes (from low to high) of revegetation prospects. The first 2 classes (ranked high to very high) were represented by all of our high elevation sites. This outcome is indicative of the elevation-precipitation and elevation-evaporation relationships so important in Utah. The remaining classes characterized sites at lower elevations, and class differentiation at these sites appears to be controlled more by the ranges of infiltration capacity than by precipitation or evaporation."

By mid 1978 the researchers hope to be able to reliably classify most of the important spoils or tailings deposits in Utah. Their classification can then be used to decide which sites are most likely to respond positively to costly rehabilitation efforts.

More for Less

You might think that by now, after thousands of years of practice, we would know all there is to know about irrigation technology. 'Tain't so!

And besides, irrigation procedures that were "good enough" a couple of years ago, are becoming unacceptable because of the energy, water, or labor shortages projected for much of the world. At the same time, the demand for food from irrigated agriculture continues to rise.

To meet these new circumstances, USU Agricultural and Irrigation Engineering faculty members, Glen E. Stringham and Jack Keller, together with their graduate assistant, Glen Dobbs, have been working to develop a new, innovative, gated-pipe irrigation system. Results of their preliminary tests are encouraging.

In effect, their completely portable irrigation system is designed with economics in mind, and should save irrigators time while assuring a more efficient use of available water. As Dr. Stringham says, "Our system works well with no more than a 4-6 ft head of water, which eliminates the high energy costs often associated with sprinkler irrigation. It also does away with the double pipelines that are an integral part of current automated gated-pipe irrigation systems."

The researchers are investigating several techniques for controlling the flow of water from each individual gate into each furrow or basin. The gate can be turned fully on, fully off, or adjusted to give an average flow of water anywhere in between. Thus, irrigation can be started with a large stream of water and finished with a smaller stream, which means more efficiency. This is called cut-back irrigation, and it reduces water losses to deep percolation, as well as the amount of runoff water.

According to Dr. Keller, "We are also working on control systems that will incorporate with our automatic gates. While this may appear to be space-age thinking, we believe it represents the direction of irrigation in the not-too-distant future. Of course, all of this must be done within a competitive economic framework and that's exactly what we hope to accomplish."

Since they are still in the test phase of their research activities, Professors Keller and Stringham estimate that the USU gated-pipe automatic irrigation system will probably not be ready for a full-scale pilot operation before the summer of 1979. Depending upon the success of that operation, the system should reach the retail market in the early 1980s. Another couple of years, however, doesn't seem overly long to wait when the promise is of such a major improvement in the average surface-irrigation cost/benefit ratio.

A Question of Time

Whose time is worth more these days—that of a fence-riding cowhand, an unskilled construction laborer, or a family-sustaining homemaker? Well, as of this moment, no one can give an unequivocal answer. And in our acutely money-conscious culture, that can be a momentous handicap.

The problem is, if an item or a service can't be assigned a dollar value, most of us tend to dismiss it as (at best) unimportant or (at worst) expendable. Currently, homemakers, scenery, and certain recreational pursuits are representative of the kinds of entities suffering from a lack of dollar valuation.

For homemakers, the difficulty lies in a lack of time/chore data. No one knows the precise time investments that have to be made per what activities if a family is to function as a congenial unit. We do know that our new time-saving household appliances haven't been able to keep pace with our new time-consuming lifestyles. Or at least that was the case in 1967-1968 when a New York state survey showed that homemakers were devoting as many hours at that time to housekeeping as they did in the 1920s.

Does that pattern still hold in 1977-1978? USU researcher Jane McCullough, Assistant Professor of Home Economics and Consumer Education, is participating in a series of nationwide studies that should answer that question—and others.

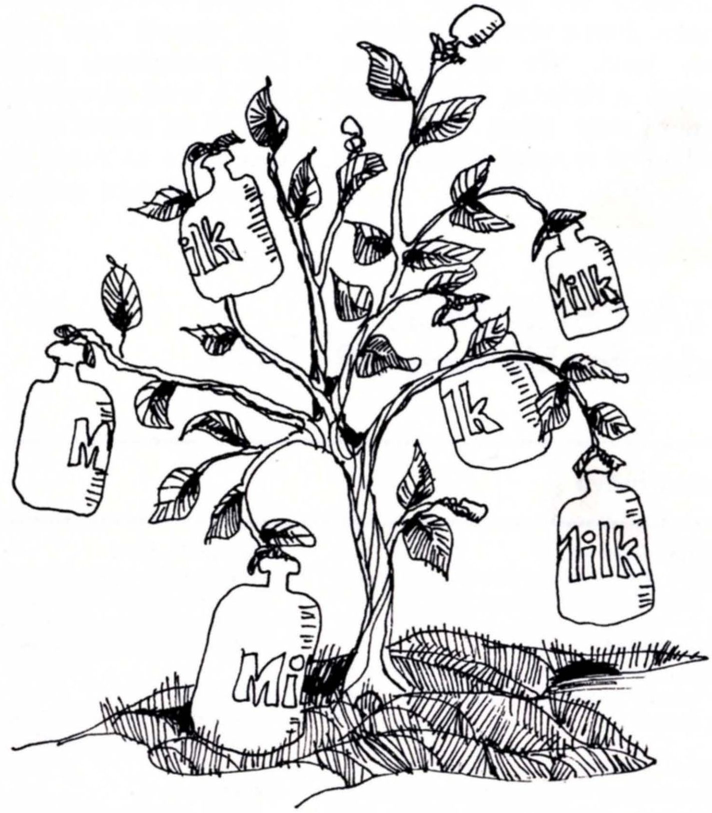
The survey, which will be completed in early 1978, is involving 210, 2-parent, 2-children families in Salt Lake, Washington, and Iron counties. So far, those families have completed enough time-accounting sheets and questionnaires to give several file cabinets that "stuffed" feeling.

The time accounting sheet included in each family's packet is designed to find out how each member of the family (6 years old and older) uses two 24-hour days, with each hour broken into 10-minute segments. The questionnaire sheets are gathering information about the family's possessions and income and the attitude of each adult member toward housework.

Although the survey is still in progress, the researchers have recognized some apparent trends. One of them is that most families (rural and urban alike) are adhering to the traditional view of housework being the woman's responsibility, whether or not she works outside the house to augment the family's income. Relative to time requirements, earlier (1967-1968) studies had shown that a fulltime homemaker put in about 8 hours per day at domestic chores, while one with outside employment spent about 5 hours per day. The 1977-1978 survey seems likely to produce comparable data.

It also seems that, in Utah at least, there is not always a consensus between husband and wife as to the ideal allocation of tasks in the home. Many wives would like their husbands to participate more than they do in household activities. Husbands, on the other hand, are rarely in favor of such sharing.

Whatever its ultimate philosophical implications, however, completion of the nationwide investigation should make a useful start towards putting dollar signs on the worth of a homemaker's time.



Cottonseed=Milk?

It began about 12 years ago with cotton-growing dairymen in California and Arizona. It invaded Utah about 5-6 years later.

What is *it*?

It is the practice of substituting unprocessed cottonseed for part of the grain that is fed to high producing dairy cows. The dairymen who are using the cottonseed believe it gives them better production than the usual concentrate (grain) supplement. Strangely enough, no one had looked intensively for scientific proof (or disproof) of that conviction until Melvin Anderson, Federal Collaborator with the Agricultural Research Service began his long-term program of feeding trials in 1976.

His first 2-month trial was with cows that were in their decreasing phase of production. The control animals received the normal grain mix in amounts geared to their individual production levels. The other cows had 1.8 kg (4 lb) of cottonseed substituted for 1.8 kg (4 lb) of their allotted, production-matched grain concoction. Those receiving the cottonseed did produce more milk per day and their production levels declined more slowly than those of the control cows.

The study results were less than definitive, however. For one thing, because the cows getting cottonseed were producing more milk, they received more total cottonseed/grain than did the control group. So it *could* have been the higher total energy of their ration that kept their production up.

Dr. Anderson and a graduate student (Donald Adams) are currently feeding two groups of cows rations that are equal in total energy, but vary in having or not having a cottonseed component. The results of this trial are expected to define whether it is the *form* of energy provided by the cottonseed that is its plus factor. Subsequent trials will test the specific worth to the cows of the protein and fiber contents of the cottonseed.

According to Dr. Anderson, "Eventually we want to also define just how much of the cottonseed is needed to optimize results. It is possible, even likely, that at some level of feeding, the cottonseed will produce fewer benefits than it does at a slightly lower level. We are also interested in defining how its fiber content may affect the cow's need for other roughages (hay)."

Another graduate student (M. Khoylos) is checking on how effectively young calves can digest the cottonseed. Their long-range goal in the calf trials, says Dr. Anderson, ". . . is to gain more insights into rumen development and growth rate relationships. Our preliminary results indicate that a level of cottonseed up to 1/3 of an animal's total grain intake gave us more growth than did the 'straight' grain allotment."

Obviously, cows can indeed convert unprocessed cottonseed into milk. And when Dr. Anderson and his students finish their feeding trials, we should have a reasonably good idea of how to help them to do it in the most efficient way. The data could also be applied in future studies that would determine the point at which feeding cottonseed would be economically impractical despite its positive effects on production.

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Agricultural Experiment Station
UTAH STATE UNIVERSITY
LOGAN, UTAH 84322

Doyle J. Matthews
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